Final James Island
Beneficial Use of Dredged Material

Consolidated Reconnaissance Report

Prepared for

Maryland Port Administration
2310 Broening Highway
Baltimore, MD 21224

Under Contract to

Maryland Environmental Service
2011 Commerce Park Drive
Annapolis, MD 21401

Prepared by

EA Engineering, Science & Technology, Inc.
15 Loveton Circle
Sparks, MD 21030

MES Contract # 02-07-10
MPA Contract # 500912
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EXECUTIVE SUMMARY

James Island is an eroding island that has been identified by the Maryland Port Administration's (MPA) Dredged Material Management Program (DMMP) process as a potential option for island habitat restoration through the beneficial use of dredged material. In addition, the Dorchester County Resource Preservation and Development Corporation (DCRPDC), a non-profit organization, had originally recommended and presently supports James Island as a possible habitat restoration project using dredged material. The DCRPDC is interested in stabilizing and protecting the Dorchester County shoreline, but does not have any ownership interest in James Island (MES 2002). In addition to support from DCRPDC, DMMP, and MPA, the private landowners of James Island indicate their support of the proposed habitat restoration project as well. Following the recommendation of James Island as a restoration project, reconnaissance level studies for evaluating the island as a potential beneficial use site were initiated in Spring 2001. The designation of James Island as a preferred option for habitat restoration using dredged material was the result of conceptual studies and evaluation by technical management and citizens in the DMMP process. Reconnaissance studies were then initiated on the option.

James Island currently consists of three eroding island remnants. The island remnants are located in Dorchester County, Maryland east of the mouth of the Little Choptank River. The existing remnant islands were formed as a result of natural processes of shoreline erosion that affect the Chesapeake Bay region. Historic and current mapping of the island has indicated that over 800 acres of the island have eroded away since 1847. James Island was estimated at 976 acres in 1847 and recent estimates from 1994 measure the island at 92 acres.

EA Engineering, Science, and Technology, Inc. (EA) was contracted by Maryland Environmental Service (MES) to complete a reconnaissance study and consolidated report that includes all current studies of James Island as a prospective habitat restoration area using dredged material from the outer approach channels to the Baltimore Harbor (east of North Point/Rock Point Line in the Patapsco River). These studies were conducted to support the MPA DMMP process. This consolidated report combines the findings of several separate investigations and includes the following studies: subsurface geotechnical investigations, coastal engineering investigations, hydrodynamic and sedimentation modeling, dredging and site engineering (including design and cost specifications), and the existing environmental conditions at James Island. This report includes investigations and modeling studies that have either been updated or completed since the Conceptual James Island Beneficial Use of Dredged Material Report was prepared by MES. A total of 5 alignments with two dike elevations and a 50 percent upland to 50 percent wetland ratio are currently being considered.

Site visits to James Island were conducted by MES in June 2001 and by EA in the Fall of 2001 and Summer of 2002, during the seasonal sampling surveys. Initial site visits and reconnaissance survey demonstrated that James Island is primarily forested. The shoreline consists of fringe marshes and eroding wooded banks lined with submerged snags in the adjacent waters. The shoreline elevations range from 5 to 10 feet (ft) in height on the northwestern shores and gradually decrease to the south. The surrounding waters are relatively shallow and range from 3-12 ft. Natural oyster bars (NOBs) are located in the general vicinity. The island is currently used for recreation such as hunting and fishing. Natural habitats include forested uplands, wet meadows, submerged aquatic vegetation (SAV), tidal marshes, coves, and some sandy beach areas.

A Geotechnical Reconnaissance Study was conducted by Engineering, Construction, Consulting, and Remediation, Inc. (E2CR) to evaluate subsurface conditions along the five proposed dike alignments for construction at James Island. This geotechnical investigation focused on the suitability of foundation soils for supporting dike construction, the availability of suitable borrow to construct a dike system, and the development of a preliminary dike section. The foundation soils in most areas consisted of silty sand, which is suitable for supporting a dike. However, some soils were soft silty clays at the mud line that would require undercutting and backfilling with sand. The site contained a sufficient quantity of suitable borrow for constructing the perimeter dike to an elevation of 20+ ft. The net quantity of sand available was approximately 12+ million cubic yards (mcy). For this reconnaissance phase, it was assumed that the dike would be constructed by hydraulic dredging, and the slopes achievable would be 3H:1V above and below the water table.

A Coastal Engineering Reconnaissance Study was conducted by Moffatt and Nichol Engineers (MNE) to evaluate the five alignment options for beneficial use of dredged material at James Island. This investigation included an evaluation of existing physical site conditions, relevant bathymetry, wind, water level and geotechnical data for evaluation of wave height and dike construction requirements, and designs of proposed dike alignments and typical cross-sections. Waves were hindcast for eight directional windspeeds using methods recommended by the U.S. Army Corps of Engineers (USACE). The highest waves for the site approach from both the north and south. From these wave forecasts, seven preliminary cross-sections were developed for the containment dikes. The dike designs are based upon a 35-year return period. Dike heights are based on allowable overtopping for an unarmored crest and an allowance for settlement. The dike design also incorporates 3:1 side slopes, above grade toe protection, a core constructed of sand, and a crushed stone roadway on the structure crest. Overall, seven dike cross-sections were designed for the five proposed alignments. Each alignment would require four to five different dike cross-sections for construction. Should this study move forward to feasibility, recent bathymetric surveys conducted within the vicinity of James Island are recommended to be used.

A Hydrodynamics and Sedimentation Modeling Reconnaissance Study was conducted by MNE to evaluate the projected hydrodynamic changes at James Island if construction of the various alignments takes place. The MNE Upper Chesapeake Bay – Finite Element Model was used to predict existing conditions as well as with- and without-project hydrodynamics and sedimentation for each of the five proposed alignments (MNE 2000). The modeling results for the James Island habitat restoration project show minimal impacts on local tidal elevations, which are essentially unchanged. Current velocities are impacted following island construction, with a maximum increase or decrease in current velocity of about 0.4 ft/second (sec). The project construction at James Island would have beneficial effects on sedimentation rates and patterns, with less erosion of the James Island shoreline and the shallow areas surrounding the remnants. Some protection would also be afforded to the shoreline of Taylors Island from wind and waves coming from the N, NNW, and NW directions. This reduction in erosion would likely reduce suspended sediment and improve water quality in the surrounding area.

A Dredging and Site Engineering Reconnaissance Study was conducted by Gahagan and Bryant Associates, Inc. (GBA) to summarize the dredging and site engineering aspects of restoring and developing habitat at James Island using dredged material. The study presented five proposed alignments and their associated costs to assist decision-makers in selecting the site layout to be carried to the final design. Each of the five alignments included a wetland and upland cell designation, with a 50 percent upland to 50 percent wetland ratio. In addition, two different upland dike heights were examined for the five alignments and included a 10-ft and 20-ft dike height alternative for each alignment. For the 10-ft upland dike elevation alternative, the site capacity for the five alignments ranged from 23 to 52 million cubic yards (mcy). For the 20-ft upland dike elevation alternative, the site capacity for the five alignments ranged from 35 to 79 mcy. The total site areas for the alignments range from 979 to 2,202 acres. Alignment 1 is the smallest layout and would have a footprint of 979 acres, Alignment 2 would have a footprint of 2,127 and Alignment 3 would have a footprint of 1,586. Alignment 4 is the largest of the five site designs and is a variation of Alignment 2 that would have a footprint of 2,202 acres. Finally, Alignment 5 is a variation of Alignment 4 and would have a footprint of 2,072 acres. The site operational life of all five alignments is estimated between 13 and 15 years with respect to the 10-ft dike elevation, and between 20 and 23 years with respect to the 20-ft dike elevation.

The 10-ft mean lower low water (MLLW) dike elevation total estimated costs for the project range from $406 million to $759 million. The schedule for construction is 2.3 to 3.2 years and is dependent upon the borrow method used. The easiest, quickest, and least costly borrow source is onsite borrow. The total costs per cubic yard (cy) of site capacity range from $14/cy to $18/cy. The 20-ft MLLW dike elevation total estimated costs for the project range from $591 million to $1.106 billion. The time required for construction is 3.0 to 3.7 years and is dependent upon the borrow method used. The total costs per cubic yard (cy) of site capacity range from $14/cy to $17/cy.

The Existing Environmental Conditions Study investigated the current conditions and the potential impacts of the proposed project. This reconnaissance level study includes information obtained from conceptual studies, literature reviews, and observations from previous field investigations. Several site visits to James Island have been conducted to assess the environmental conditions of the island remnants and to document the terrestrial and aquatic resources present in and around the project area. This report includes observations from a site visit conducted by MES in June 2001 and two site visits conducted by EA in the Fall of 2001 and the Summer of 2002, as part of seasonal sampling for feasibility evaluations. Components of these investigations included vegetation identification and mapping, avian and wildlife utilization surveys, fisheries and plankton sampling, benthic invertebrate studies, sediment and water quality investigations, historic and recreational resource evaluations, and submerged aquatic vegetation (SAV) mapping.

The current condition of James Island includes significant and severe erosion along the northern and western shorelines of the island remnants. The island remnants currently support SAV growth along the eastern shorelines and are composed of monotypic beds of widgeon grass (*Ruppia maritima*). The fisheries investigations of the island's shorelines indicated that the remnants supported a fairly diverse fish community, including juveniles of commercially important species. All collected fish species were typical of the region. In addition, avian utilization of the island was typical for this area of the Bay as well, including the federal and Maryland state-listed threatened species, the bald eagle. Bald eagles were observed utilizing the area in and around James Island. Also, an active eagle nest with a fledgling was observed on the middle remnant of James Island. Several other avian species identified at James Island during the Fall 2001 and Summer 2002 surveys have conservation status determinations associated with their breeding status. However, avian utilization of the open water areas of the proposed alignments was minor compared to that of the wetland and forested areas of the island. Three NOBs are located in the vicinity of the island remnants but not within the concept areas. Ichthyoplantkton densities were relatively high and were dominated by the bay anchovy (*Anchoa mitchilli*). Zooplankton collected were typical of the region. In general, the benthic community was typical of this area of the Bay but was dominated by a single species at most stations, the gem clam (*Gemma gemma*). The majority of the benthic species found were stress-tolerant, resulting in low Benthic Index of Biotic Integrity (B-IBI) scores at most locations. B-IBI scores of 3.0 or greater are considered as meeting the Chesapeake Bay Restoration Goal. Total B-IBI scores were low (1.0 – 1.8) for 9 of 10 stations sampled at James Island in October 2001. One station had a total B-IBI score of 3.0, and was the only station sampled in the footprint area to meet the Chesapeake Bay Restoration Goal.

Additionally, archeological sites including an oyster shell midden and historic foundations are present on the island, but are not located in the concept areas. Potential impacts that may be a concern to the aquatic and terrestrial wildlife include short-term water and sediment quality effects, and the temporary displacement of wildlife. There is also a potential to displace some commercial crabbing within the proposed habitat restoration area.

This study and the analyses of its results were conducted at a reconnaissance level. Therefore, the following report, results, and conclusions should be considered preliminary. The completed construction of the facility should improve water quality in the area by reducing erosion and the resulting suspended solids, which may help sustain or improve the oyster and clam fisheries in the area. In addition, construction of a beneficial use of dredged material project at this site would be expected to provide additional natural habitat, including both wetland and upland areas.

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APPENDICES

1.0 INTRODUCTION

1.1 Site Location

James Island is located in Dorchester County on the Eastern Shore of Maryland at the mouth of the Little Choptank River in the Chesapeake Bay (Figure 1-1). Historic and current mapping of the island has indicated that close to 900 acres of the island has eroded away since 1847. James Island currently consists of three remnants that together total less than 100 acres. The existing remnant islands were formed as a result of natural processes of shoreline erosion that affect the Chesapeake Bay region and are referred to as the northern, middle, and southern remnants, for the purposes of this discussion. James Island lies approximately one mile north to northwest of Taylors Island, and historically, the island formed a peninsula off the northern end of Taylors Island, enclosing Oyster Cove. Survey data from the Maryland Department of Natural Resources (MDNR) indicated that by 1847 the connection to Taylors Island was nearly breached and the island landmass was approximately 976 acres; by 1942, the connection had been completely breached and converted to open water. Between the years 1847 and 1994, MDNR has estimated that 884 acres of James Island were lost to erosion at an average rate of six acres per year. The island currently suffers additional erosion as a result of tropical storms and hurricanes.

1.2 Purpose and Needs

The Maryland Dredged Material Management Program (DMMP) and its participants have identified islands in the Chesapeake Bay for reconnaissance studies as island habitat restoration areas using dredged material. Mr. Joe Coyne, President of the DCRPDC, a non-profit citizens' organization, suggested the possibility of an island habitat restoration project at James Island to potentially stabilize and protect Dorchester County shorelines. In October 2000, the MPA and the Maryland Department of Transportation (MDOT) completed a report to the Maryland General Assembly Senate Budget and Taxation Committee and House Appropriations Committee regarding the Governor's Strategic Plan for Dredged Material Management. This report identified James Island as a potential option for a habitat restoration project using dredged material (MPA 2000). In addition to support from the DCRPDC, the MDOT and the MPA, the current, private landowners of James Island have indicated their support of the proposed island habitat restoration project using suitable dredged material.

The reconnaissance configurations currently being considered for the James Island restoration project include a 50 percent upland to 50 percent wetland ratio project utilizing 23 to 79 million cubic yards (mcy) of suitable dredged material. Five preliminary dike alignments (referred to as footprints) are presently being considered (Figure 1-2). The design acreages for the alignments range in size from 979 to 2,202 acres and are predominantly located in the open water area to the west of the James Island remnants.

1.3 Scope of Project

EA was contracted by Maryland Environmental Service (MES) to complete a consolidated report that includes all current studies of James Island as a prospective habitat restoration area using

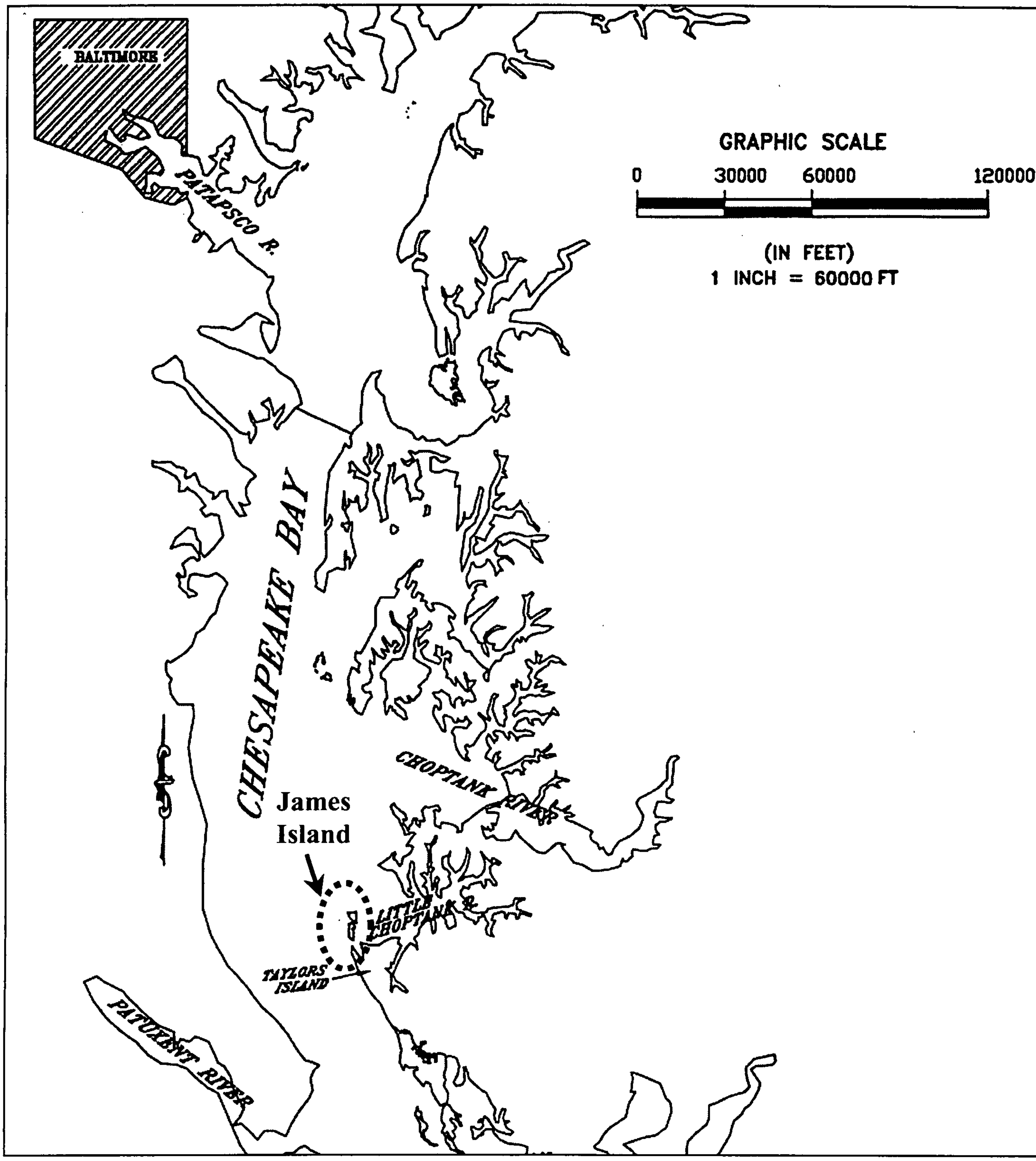

Figure 1-1. Location of James Island, Dorchester County, MD

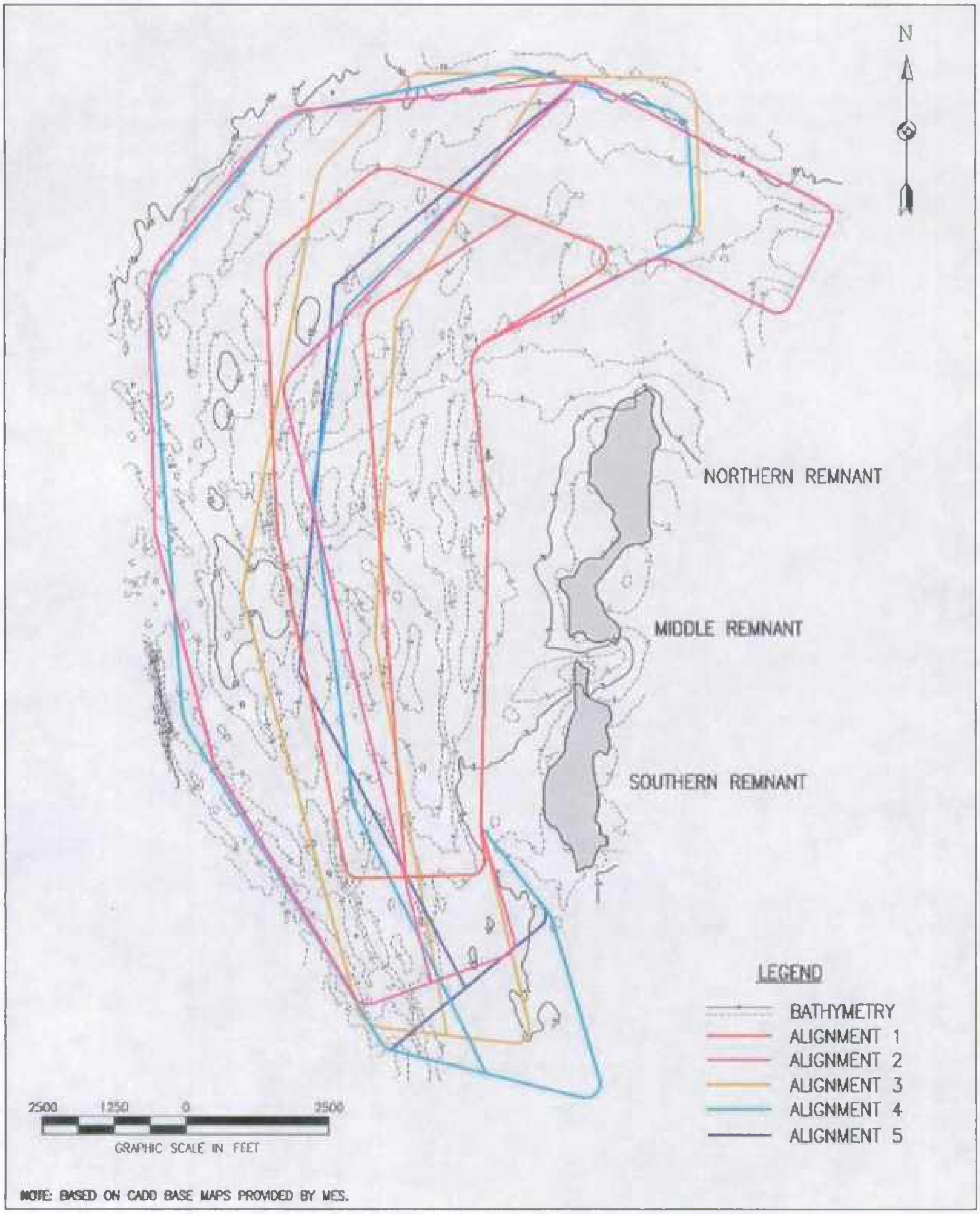

Figure 1-2. Proposed Placement Areas at James Island

material dredged from the approach channels to the Baltimore Harbor. These studies were conducted at a reconnaissance level at the request of the MPA. This report combines the findings of several separate investigations and includes the following studies: subsurface geotechnical investigations, coastal engineering investigations, hydrodynamic and sedimentation modeling, dredging and site engineering (including design and cost specifications), and the existing environmental conditions at James Island. The individual studies discussed in this report are included in their entirety in Appendices A through F. Five proposed alignments were assessed. The proposed alignments are outlined in Section 2.3, Section 6.0, and detailed in Appendix D. The environmental conditions study includes an on-site visit by MES staff during June 2001 (Appendix E) and two seasons of environmental sampling during Fall 2001 and Summer 2002 by EA Engineering (Appendix F). During the site visits, environmental scientists observed and explored all three island remnants and shorelines extensively. The findings for each of these technical areas are summarized in the following sections.

2.0 JAMES ISLAND SITE DESCRIPTION

2.1 Bathymetry and Topography

The James Island remnants are currently less than 100 acres in total size and are decreasing annually due to erosion (Stevenson and Kearney 1996). The shoreline consists of eroding fringe marshes and tidal marshes, eroding sediment banks, and eroding wooded upland banks. The eroded banks of the northern remnant have the highest elevation of 5 to 10 ft. Bank elevations decrease gradually in a north to south direction. Prior to its separation from Taylors Island, James Island was once a peninsula enclosing Oyster Cove.

Hydrographic data were obtained from the National Oceanic and Atmospheric Administration (NOAA) and National Ocean Service (NOS) charts 12230 and 12263. Vertical and horizontal data were referenced to MLLW based on the 1960 to 1978 tidal epoch and the Maryland State Plane, North American Datum of 1983. Water depths within the proposed site area vary between –2 to –12 ft MLLW. The maximum water depth where the exposed dike would be constructed is about –12 ft MLLW and water depths approximately one mile west of James Island are as great as –93 ft MLLW (See Appendix B for details). Water depths are variable to the east and uniform to the west of the remnants.

2.2 General Site and Habitat Descriptions

James Island currently consists of three eroding island remnants. The northern two remnants are joined by a sandy beach spit that terminates into a high-low marsh complex with brackish, open water tidal ponds. Mixed forest stands dominated by loblolly pine (*Pinus taeda*) are located in the interior portions of the three remnants. Small patches of high marsh can be found on all three remnants, with the southern remnant possessing a fairly extensive marsh complex in the center. A wet meadow is located in the northern portion of the northern remnant and contains emergent freshwater vegetation in standing water during wet seasons. The shorelines consist of fringe marshes and eroded wooded banks of 5 to 10 ft elevations lined with submerged snags in the adjacent areas. The elevation of the shoreline gradually decreases from the northern to the southern remnants. The majority of the steep, wooded banks are located on the northern remnant, while most of the southern remnant shoreline consists of fringe marsh. The northern and western shorelines of each remnant exhibit the most severe erosion and many downed trees are located in the water in these areas. There is evidence that a fairly recent fire has killed many trees and impacted some of the marsh areas on the northern and southern remnants.

Normal water level variations in the Chesapeake Bay are generally dominated by astronomical tides, although wind effects and freshwater discharge can also be important. Astronomical tides in the Chesapeake Bay are semi-diurnal; the mean tide level is 0.9 ft above MLLW and the mean tidal range is 1.1 ft (NOS 1997). In the James Island project vicinity, the mean range of tides is 1.3 ft, the mean tide level is 0.9 ft above MLLW, and the spring tidal range is 1.8 ft. Currents in the project vicinity (approximately 2.5 miles west of James Island) are less than 1 ft/sec (NOS 1996), which are rated as relatively moderate to weak.

SAV was observed at three individual areas along the eastern shoreline of the northern, middle, and southern remnant islands. Few aquatic features are present in the project vicinity besides downed trees in the adjacent waters. However, three state-recognized NOBs are located in the general vicinity of James Island, outside of the five proposed alignments. There were no standing structures observed on the island remnants during site visits, although evidence of past brick foundations observed indicates that dwellings did exist on the island in the past. The three privately-owned remnants are currently used for recreational hunting and fishing.

2.3 Proposed Site Alignments

Five potential alignments were considered for this study and are discussed in the GBA report included as Appendix D of this report. The five proposed dike alignments, which are predominantly located in the open water area to the west of the island remnants, and the existing bathymetry in the general project area, are presented together in Figure 1-2. Each of the five alignments includes a wetland and upland cell designation, in a 50 to 50 percent ratio. It was assumed for all five alignments that the wetland cells would be located on the eastern side of the footprint and would require a maximum 8-foot dike height for wave protection, similar to the Poplar Island Environmental Restoration Project (PIERP). Two different upland dike heights were examined for the five alignments and include a 10-ft and 20-ft dike height alternative for each alignment. The preliminary alignments considered for this study include utilizing 23 to 52 mcy of suitable dredged material for the 10-ft dike height and 35 to 79 mcy for the 20-ft dike height. The total acres for the footprints of each of the five alignments and the wetland and upland cell sizes are discussed in the following text and Table 2-1.

Alignment 1 is the smallest layout studied here and would have a design acreage of 979 acres. The Alignment 2 site layout would have a design acreage of 2,127 acres, a boundary of James Island to the east, deep water to the west, NOBs to the north, and a local navigation channel to the south. The Alignment 3 site layout is a variation of Alignment 2 and would have a design acreage of 1,586 acres. Alignment 3 would have a boundary of James Island to the east, NOBs to the north and Taylors Island to the south. Alignment 4 is the largest of the five site designs and is a variation of Alignment 2. It has a boundary of James Island to the east, deep water to the west, NOBs to the north and connects to Taylors Island to the south. Alignment 4 would have a design acreage of 2,202 acres. Alignment 5 is a variation of Alignment 4 and would have a design acreage of 2,072 acres. Alignment 5 would have a boundary of James Island to the east, deep water to the west, NOBs to the north and a local navigation channel to the south. The capacities and estimated costs for each alignment are discussed further in Section 6.0.

TABLE 2-1. TOTAL DESIGN ACREAGES FOR THE FIVE PROPOSED ALIGNMENT FOOTPRINTS, UPLAND ACREAGES, AND WETLAND ACREAGES AT JAMES ISLAND

Alignment Number	Total Design Acreage	Total Upland Acreage	Total Wetland Acreage
1	979	489	489
2	2,127	1,063	1,063
3	1,586	793	793
4	2,202	1,101	1,101
5	2,072	1,036	1,036

3.0 SUBSURFACE GEOTECHNICAL RECONNAISSANCE STUDY

3.1 Introduction

A Geotechnical Reconnaissance Study was conducted by E2CR to evaluate the suitability of foundation soils for supporting dike construction at James Island. The full geotechnical report, tables, and figures are included in Appendix A. The layouts of the five dike alignments were evaluated for this study. These five dike alignments enclose areas ranging from 979 to 2,202 acres. The dikes are proposed to be constructed by hydraulically or mechanically dredging sand from a borrow area, stockpiling the sand if necessary, and hydraulically or mechanically depositing the sand along the dike alignment. Hydraulic placement offers construction advantages and was used for analytical purposes in this study. Use of mechanical dredging would change the properties of the sand to be used in dike construction would require an additional study to evaluate dike stability. The outside face of the dike will be protected from wave action by armor stone and the top of the exterior dike enclosure is expected to vary from an elevation of 5 to 20 ft. For this reconnaissance study, the maximum dike elevation of 20+ ft was assumed.

3.2 Purpose and Objectives

This study focused on the subsurface conditions along each of the proposed alignments. It includes the suitability of foundation material for supporting the dike, availability of suitable borrow to construct the dikes, and development of a preliminary dike section. A total of 22 borings were drilled to depths of 27.5 to 70-ft below the water surface. Core samples were collected and laboratory testing was performed to evaluate the classification, shear strength, and compressibility of selected sub-samples. Laboratory tests were also conducted to determine stress history, strength characteristics, index properties of various strata, and suitability of borrow area materials. Electric Cone Penetrometer tests were conducted at four locations and *in-situ* vane shear strength tests were conducted at eight locations to support these field investigations.

The objectives of the reconnaissance geotechnical investigation were:

- To evaluate the geotechnical conditions at the site, especially along the proposed alignments,
- To design a stable dike section for the site in order to establish a preliminary cost estimate for developing the site, and
- To evaluate the availability of borrow material (sand) at the site for subsequent dike construction.

The five proposed dike alignments are illustrated in Figure 1-2.

3.3 Subsurface Conditions

The subsurface conditions along the perimeter of the dike and in the potential borrow area (within the diked area) are significantly different and are therefore, discussed separately.

3.3.1 Foundations

The borings drilled along the proposed dike alignments indicate that the foundation soils in most areas consist of silty sand, suitable for supporting the dike. Some of the borings, however, encountered soft silty clays at the mud line that would require undercutting and backfilling with sand. For these areas, the depth of required undercut was anticipated to range from 5+ to 15+ ft with an average of about 10 ft.

The test boring locations around James Island are mapped in Appendix A, Figure 5.

3.3.2 Borrow Areas

The site was found to contain a sufficient quantity of suitable borrow for constructing the perimeter dike to an elevation of 20+ ft. Suitable borrow was defined as sand with less than 30% fines. It is estimated that the total borrow sand available is about 15 mcy. The net quantity of sand available (assuming a 15% loss of fines during construction) will be about 12+ mcy.

There are four potential sand borrow sites within the vicinity of the James Island project. Two of the sites are located north and west of James Island and two are located southeast and southwest of the Island. The northern location has a total volume of 14.2 mcy, the western location has a total volume of 1.1 mcy, the southeast location has a total volume of 1.0 mcy, and the southwest location has a total volume of 0.3 mcy.

Locations of potential borrow areas around James Island and a summary of borrow area materials are presented in Appendix A, Figure 11 and Appendix A, Table 4.

3.3.3 Slope Stability

A slope stability analysis was performed to develop a preliminary design section for the perimeter dike. For this reconnaissance phase, it was assumed that the dike would be constructed by hydraulic dredging, and the slopes achievable would be 3H:1V above and below the water table.

Summaries of slope stability analyses for exterior dikes of 20 and 10 ft are presented in Appendix A, Tables 6 and 7.

3.4 Conclusions

Based on the limited boring data, the foundation materials for the proposed dike alignments are anticipated to be loose, silty sands. In three of the 22 boring sites, substrates were silty clay. The silty sands are considered to be suitable for supporting the proposed dikes with an exterior slope of 3H:1V and the top of the dike at an elevation of 20+ ft. A total of 15 mcy of silty sand and a net (i.e., assuming 15% loss during hydraulic dredging and placement) of 12+ mcy of silty sand is available within the diked area.

4.0 COASTAL ENGINEERING INVESTIGATION

4.1 Introduction

A Coastal Engineering Reconnaissance Study was conducted by MNE to evaluate five alignments for beneficial use of dredged material at James Island. This reconnaissance assessment includes an evaluation on existing data pertaining to environmental site conditions and coastal engineering aspects of dike design. It also includes a review of environmental, geotechnical and dredging engineering studies previously conducted for the site, and the design of potential containment dikes with regards to armor protection and structure height. The full coastal engineering report, tables, and figures are included in Appendix B.

This reconnaissance study used available site data of bathymetry, water levels, and wind conditions to hindcast waves for the site. Waves were also hindcast based upon wind data and results from previous studies of storm-induced water levels in the Chesapeake Bay. Offshore and nearshore waves were hindcast for the appropriate winds along the five proposed dike alignments. These hindcast wave conditions were subsequently used to prepare the reconnaissance design for the five dike alignments that would be used to contain the dredged material. The design parameters evaluated for this study included alignment location, crest height, structure slope and armor stone size.

4.2 Purpose and Objectives

The purpose of the investigation was to provide a preliminary coastal engineering analysis of James Island as a potential site for beneficial use of dredged material and to decide if further evaluation of any of the design concepts is warranted. This assessment included an evaluation of existing environmental site conditions, relevant bathymetric, wind, water level and geotechnical data for evaluation of wave height and dike construction requirements, and designs of proposed dike alignments and typical cross-sections.

The overall objectives of this study were:

- To analyze site bathymetry, water levels and wind conditions
- To hindcast offshore and nearshore waves at the project site
- To calculate dike design parameters
- To define the minimum safe dike elevation to prevent wave run-up and overtopping.

The five proposed dike alignments are illustrated in Figure 1-2.

4.3 Coastal Conditions

Water depths in the area where the dikes would be located range from –2 to –12 ft MLLW, with an average depth along the exterior dikes ranging from –3 to –12 ft MLLW. Normal water elevations at the site are dictated by astronomical tides. Mean tide elevation is 0.9 ft above MLLW. Design water elevations for the project area are dominated by storm surge, which can be as high as 5.6 ft above MLLW for a 100-year return period. Currents in the project area are relatively weak, with a maximum velocity of 1 ft/sec, and are not considered critical to the design of shore protection. However, current patterns could be affected by island restoration. The effects of the dike construction will be discussed in the Hydrodynamics and Sedimentation Modeling Report (Section 5.0) of this study.

Design winds for the site were developed from data collected at Baltimore-Washington International (BWI) Airport. Design wind speeds are calculated for return periods ranging from 5 to 100 years for eight wind directions, including the direction with the longest fetch (south).

Waves were hindcast for the eight directional design windspeeds using methods recommended by the USACE, published in the *Shore Protection Manual* (USACE 1984). For Alignments 1, 2 and 3, the highest offshore waves approach from the north and south. However, Alignments 4 and 5 have relatively larger depths for the southwest direction thus the largest nearshore waves for these alignments are from the southwest direction. Shallow bathymetry in the vicinity of the site requires calculation of nearshore wave spectra. Predicted peak spectral wave period for all five alignments ranges from a minimum of 4.9 seconds for a 5-year storm, to a maximum of 6.4 seconds for a 100-year storm. Significant offshore wave height ranges from 3.9 ft (Alignments 4 and 5) for a 5-year storm to 11.0 ft (Alignments 4 and 5) for a 100-year storm.

Results of the preliminary geotechnical study by E2CR indicated that the underlying sediment is silty sand. There are, however, areas with soft silty clays at the mud line that will need to be undercut and backfilled with sand.

Further derivation of wave conditions and wave hindcast results for the five proposed dike alignments are presented in Appendix B. A detailed discussion of site conditions is presented in Section 2.0 of this report. These include bathymetry and topography, wind conditions, water levels, astronomical tides, storm surge, tidal currents, and substrate characteristics.

4.4 Coastal Protection Dike Design

Preliminary cross-sections were developed for coastal protection of the containment dikes. Cross-sections varied primarily in accordance with wave exposure and foundation conditions.

4.4.1 Alignments

A summary of the maximum predicted peak spectral wave period and significant wave heights for a 5-, 35- and 100-year storm event for five proposed alignments is presented in Table 4-1 of this report. The wave approach from eight directions (N, NE, E, SE, S, SW, W, and NW) is also detailed for the three return periods and five proposed alignments in Table 4-1 of this report.

Due to deeper water depths, the largest nearshore waves approach Alignments 4 and 5 from the southwest.

Details of the predicted peak spectral wave period and significant wave heights are detailed in Section 2.5 of Appendix B.

4.4.2 Dike Sections

Seven preliminary cross-sections were developed for the containment dikes. The dike designs are based upon a 35-year return period. Dike heights are based on allowable overtopping for an unarmored crest and an allowance for settlement. Stone sizes are computed using the Van der Meer method. The designs incorporate 3:1 side slope, above grade toe protection, a core constructed of sand, and a crushed stone roadway on the structure crest. A summary of the seven preliminary dike cross-sections designs is presented in Table 4-2 of this report.

Details of the seven preliminary dike cross-sections and dike section locations are illustrated in Appendix B (Figures 3-16 to 3-22 and Figures 3-11 to 3-15).

4.5 Conclusions

This Coastal Engineering Investigation indicates that construction of dikes to restore an island using dredged material project is feasible from a coastal engineering standpoint. Design of the dikes is similar to those used for the PIERP. The majority of the proposed island will be exposed to waves sufficient to require armor. The east side of the proposed island is sheltered from waves, and thus is designed with a sand dike. Five alignments were evaluated, resulting in seven dike sections with elevations ranging from +7.0 ft MLLW to +11.0 ft MLLW and armor ranging from no armor to 5,000 pound armor stone. Each of the five alignments would require four to five different dike cross-sections for construction.

TABLE 4-1. SUMMARY OF THE MAXIMUM PREDICTED PEAK SPECTRAL WAVE PERIOD (SEC) AND SIGNIFICANT WAVE HEIGHTS (FT) FOR A 5-, 35-, AND 100-YEAR STORM EVENT FOR FIVE PROPOSED ALIGNMENTS

Type of Wave Period and Height	Alignment 1*	Alignment 2*	Alignment 3*	Alignment 4*	Alignment 5*
5-year storm					
Peak spectral wave period (sec)	4.9 (N,S)	4.9 (N,S)	4.9 (N,S)	4.9 (N,S)	4.9 (N,S)
Offshore significant wave height (ft)	5.4 (N)	5.4 (N)	5.4 (N)	5.4 (N)	5.4 (N)
Nearshore significant wave height (ft)	4.6 (N)	5.0 (N)	5.3 (N)	5.1 (N)	5.1 (N)
Nearshore maximum wave height (ft)	7.6 (N)	8.1 (N)	8.7 (N)	8.4 (N)	8.4 (N)
35-year storm					
Peak spectral wave period (sec)	5.9 (S)	5.9 (S)	5.9 (S)	5.9 (S)	5.9 (S)
Offshore significant wave height (ft)	8.3 (S)	8.3 (S)	8.3 (S)	8.3 (S)	8.3 (S)
Nearshore significant wave height (ft)	5.2 (SW)	5.5 (N, SW, W)	5.9 (N)	6.5 (SW)	6.5 (SW)
Nearshore maximum wave height (ft)	8.6 (N)	9.3 (N)	9.9 (N)	10.0 (SW)	10.0 (SW)
100-year storm					
Peak spectral wave period (sec)	6.4 (N,S)	6.4 (N,S)	6.4 (N,S)	6.4 (N,S)	6.4 (N,S)
Offshore significant wave height (ft)	10.4 (S)	10.4 (S)	10.4 (S)	10.4 (S)	10.4 (S)
Nearshore significant wave height (ft)	5.7 (SW)	6.1 (SW)	6.4 (N)	7.1 (SW)	7.1 (SW)
Nearshore maximum wave height (ft)	9.6 (N)	10.2 (N)	10.8 (N)	11.0 (SW)	11.0 (SW)

Source (MNE 2002a)
*Waves approach from the: N = North, S = South, SW = Southwest, W = West.

TABLE 4-2. SUMMARY OF SEVEN PRELIMINARY DIKE CROSS-SECTION DESIGNS BASED UPON A 35-YEAR RETURN PERIOD

Dike Cross-Section	Crest (ft. MLLW)	Side Slope (H:V)	Armor Stone	Underlayer Stone	Geotextile Layer?	Description of Toe Protection
Section 1	+11.5	3:1	2 layers of 5,000 lb.	2 layers of 500 lb.	yes	▪ 2,500 lb. stone ▪ quarry run stone ▪ geotextile
Section 2	+11.0	3:1	2 layers of 4,000 lb.	2 layers of 400 lb.	yes	▪ 2,000 lb. stone ▪ quarry run stone ▪ geotextile
Section 3	+10.5	3:1	2 layers of 3,000 lb.	2 layers of 300 lb.	yes	▪ 1,500 lb. stone ▪ quarry run stone ▪ geotextile
Section 4	+9.5	3:1	2 layers of 2,500 lb.	2 layers of 250 lb.	yes	▪ 1,300 lb. stone ▪ quarry run stone ▪ geotextile
Section 5	+9.0	3:1	2 layers of 2,000 lb.	2 layers of 200 lb.	yes	▪ 1,000 lb. stone ▪ quarry run stone ▪ geotextile
Section 6	+7.0	3:1	2 layers of 700 lb.	2 layers of 70 lb.	yes	▪ 350 lb. stone ▪ quarry run stone ▪ geotextile
Section 7	+7.0	5:1	sand	sand	no	▪ sand

Source (MNE 2002a)

5.0 HYDRODYNAMICS AND SEDIMENTATION MODELING

5.1 Introduction

A Hydrodynamics and Sedimentation Modeling Reconnaissance Study was conducted to evaluate the projected hydrodynamic changes at James Island if construction of the various alignments takes place. Two models were used. The first model, the MNE Upper Chesapeake Bay – Finite Element Model (UCB-FEM), was used to predict existing conditions as well as with- and without-project hydrodynamics and sedimentation for each of the five proposed alignments. The full modeling report, tables, and figures are included in Appendix C. Site conditions that are relevant to the model are discussed in Section 2.0 and Section 7.0 of this report (e.g. bathymetry, topography, freshwater inflow, etc.).

The second model included a numerical modeling system that consisted of the USACE finite element hydrodynamics (RMA-2) and sedimentation (SED-2D) models, collectively known as TABS-2 (Thomas et al. 1985). RMA-2 is a two-dimensional, depth-averaged, finite element, hydrodynamic numerical model. SED-2D is a sedimentation model that treats two categories of sediment: a non-cohesive category for sand particles, and a cohesive category for clay particles. The non-cohesive sediment model was run using 0.1 millimeter sediment under no-wind conditions for each of 16 wind directions and wind speeds of 4-, 13-, and 16-miles-per-hour (mph). The cohesive sediment model was run for a 6-month simulation period at which point the model achieved a dynamic equilibrium (average values and rates remain steady over time). The cohesive sediment model was subsequently run for 16 wind directions and wind speeds of 4- and 13-mph.

5.2 Purpose and Objectives

The purpose of this modeling report was to analyze the projected impacts due to construction of a beneficial use and habitat restoration site at James Island with regards to hydrodynamics and sedimentation in the site vicinity. The UCB-FEM model was modified to include James Island.

The overall study objectives were:

- To compare with- and without-project tidal elevations
- To compare with- and without-project current velocities
- To compare with- and without-project relative sedimentation rates and patterns for non-cohesive and cohesive sediments

The five proposed alignments of the habitat restoration area were compared to the existing conditions at James Island, both graphically and numerically, to determine both specific and relative impacts.

5.3 Simulation Models

The numerical modeling system used in this study is TABS-2. TABS-2 is a collection of generalized computer programs and pre- and post-processor utility codes integrated into a numerical modeling system for studying two-dimensional depth-averaged hydrodynamics, constituent transport, and sedimentation problems in rivers, reservoirs, bays, and estuaries. Details concerning both model simulations and calibrations are included in Sections 4 and 5 of Appendix C.

5.4 Hydrodynamic Modeling Results

Evaluation of the potential hydrodynamic impacts of the construction of the project at James Island was conducted using the UCB-FEM model. The UCB-FEM model is used to assess potential impacts by applying identical hydrodynamic input boundary conditions to pre- and post-construction model bathymetry. Details are included in Section 6 of Appendix C. Hydrodynamic results are then used as input for the sedimentation model which is also run using identical boundary conditions for pre- and post-construction conditions. The input conditions selected represent typical hydrodynamic conditions in the vicinity of James Island.

Results of the hydrodynamic simulations are compared numerically at locations north, east and south of the project site and visually for the entire project vicinity. The following sections describe the potential impacts of the project construction for each of the five potential dike alignments on hydrodynamics. Figures of the modeling results for each alignment are presented in Sections 6 and 7 of Appendix C.

5.4.1 General Alignment Hydrodynamic Impacts

For all five proposed alignments, results from the hydrodynamics model indicate that projected water surface elevations would be unaffected by construction of the project, with relatively small impacts to current velocities since the project area is small compared to the Bay (MNE 2002b). In addition, the peak ebb and flood currents in the main Bay are not predicted to change if either of the five alignments are constructed. Following the dike construction, predicted flow would be displaced northward and southward, and current velocity would increase both north and south of the project site for all alignments. For all five proposed alignments, predicted current velocity would decrease to the east of the existing James Island remnants, where flow would be reduced by the construction of the alignments. Therefore, velocity increases are predicted around the dikes in all five alignments, but velocity decreases are predicted around the James Island remnants. Finally, the maximum predicted change around the existing island remnants for the five alignments range from 0.44 ft/sec to 0.50 ft/sec, and a lesser change is predicted in the Little Choptank River.

5.4.2 Alignment 1 Hydrodynamic Affects

For Alignment 1, the maximum velocity increases are projected at the southeast dike, between the project and the existing southern James Island, and the maximum predicted change around existing James Island is about 0.44 ft/sec; a lesser change is predicted in the Little Choptank

River. Predicted current velocity decreases primarily around the existing James Island to the east where flow is reduced by the project; to a lesser extent, velocity decreases are predicted west of the project. Comparisons of peak current velocity hydrodynamic modeling results between existing conditions and Alignment 1 for the three locations are shown in Figures 6-1 to 6-4 of Appendix C.

5.4.3 Alignment 2 Hydrodynamic Affects

Similar to Alignment 1, the maximum velocity increases are predicted at the southeast dike between the project and the existing southern James Island and the maximum predicted change around existing James Island is about 0.46 ft/sec; a lesser change is predicted in the Little Choptank River. Predicted current velocity decreases primarily around the existing James Island to the east where flow is reduced by the project, but the area where velocities are reduced is larger for this alignment than Alignment 1, as the larger project area affords more protection. Smaller velocity decreases are predicted west of the project. Comparisons of peak current velocity between existing conditions and Alignment 2 for the three locations are shown in Figures 6-5 to 6-8 of Appendix C.

5.4.4 Alignment 3 Hydrodynamic Affects

For Alignment 3, the maximum velocity increases are predicted at the southeast dike between the project and the existing southern remnant and as this alignment extends further south, the increase in velocity is concentrated at the tip of the dike, extending to Taylors Island. The maximum predicted change around existing James Island is about 0.49 ft/sec; a lesser change is predicted in the Little Choptank River. An increase in velocity is also predicted where flow is trained along the northwest dike of the project as it enters the Little Choptank River. Predicted current velocity decreases primarily around the existing James Island to the east where flow is reduced by the project, similar to Alignment 2; smaller velocity decreases are predicted west of the project. Comparisons of peak current velocity between existing conditions and Alignment 3 for the three locations are shown in Figures 6-9 to 6-12 of Appendix C.

5.4.5 Alignment 4 Hydrodynamic Affects

Alignment 4 extends furthest south towards Taylors Island, and maximum velocity increases are predicted at the southeast dike between the project and Taylors Island. The maximum predicted change around existing James Island is about 0.50 ft/sec; a lesser change is predicted in the Little Choptank River. This predicted increase in velocity is greatest among all alignments and occurs where flow is trained along the northwest dike of the project as it enters the Little Choptank River. Velocity increases are predicted around the dike in Alignment 4, but velocity decreases are predicted around the James Island remnants. This alignment provides the most protection to James Island and the greatest decrease in velocity immediately surrounding the remnants. Comparisons of peak current velocity between existing conditions and Alignment 4 for the three locations are shown Figures 6-13 to 6-16 of Appendix C.

5.4.6 Alignment 5 Hydrodynamic Affects

For Alignment 5, the reduction in velocity is similar to Alignments 2 and 3 and the maximum predicted change around existing James Island is about 0.48 ft/sec; a lesser change is predicted in the Little Choptank River. Velocity increases are predicted at the southeast dike between the project and the existing southern James Island, similar to Alignment 2. Velocity increases are also predicted where flow is trained along the northwest dike of the project as it enters the Little Choptank River. Predicted current velocity decreases primarily around the existing James Island to the east where flow is reduced by the project, similar to Alignments 2 and 3; to a lesser extent, velocity decreases are predicted west of the project. Comparisons of peak current velocity between existing conditions and Alignment 5 for the three locations are shown in Figures 6-17 to 6-20 of Appendix C.

5.5 Sedimentation Modeling Results

The UCB-FEM sedimentation model was used to examine transport of non-cohesive and cohesive materials (i.e. sand and clay), which characterize sediment in the vicinity of the project site. Examination of model results for both non-cohesive and cohesive sediments indicates that normal tidal currents are insufficient to directly cause sediment suspension and transport. Sedimentation was modeled for 0.004-inch non-cohesive sediments for 16-mph NNW, SSE and WNW winds and for cohesive sediments for 13-mph NNW, SSE and WNW winds. Sixteen-mph winds were determined to be the minimum necessary to cause sediment suspension and transport for non-cohesive sediments. Thirteen-mph winds were the minimum wind speed necessary to cause substantial sediment suspension and transport for cohesive sediments. For all five alignments, comparison of sedimentation patterns with bathymetry shows that the areas of erosion correspond to shallow water depths, while deposition occurs in adjacent deep-water areas.

The UCB-FEM sedimentation model was run for each alignment and existing conditions; each simulation began with the same initial conditions. In addition, plots showing erosion and accretion were created that depict the difference between the existing conditions and the proposed alignment (difference plot). Figures of the modeling results for each alignment are presented in Section 7 of Appendix C. The following sections describe the potential impacts of project construction for the five potential dike alignments including sedimentation for both non-cohesive and cohesive sediments.

5.5.1 General Alignment Sedimentation Affects

Non-Cohesive Sediments

For all five proposed alignments, the sedimentation model predicted that the alignments would interrupt the long NNW wind fetch from across the Bay, thereby decreasing erosion in the project area. Additionally, erosion of shallow water is decreased at a large area south of the project site extending to and along the shoreline of Taylors Island. The difference plot for NNW winds show that regions currently eroding under existing conditions will have reduced or no erosion for the with-project conditions for all five alignments. For winds from the SSE, construction of the alignments would also interrupt a large portion of the long wind fetch, decreasing the rates of erosion and accretion at James Island. For all five alignments, the region along the west dike represents an area that is currently eroding and would become an accretion area.

Cohesive Sediments

For all five alignments, the model predicted that winds from the NNW would significantly decrease erosion in the project area following construction. In addition, significantly more sediment accretion in the lee of the project site will occur, extending south to Taylors Island. The difference plot for SSE wind of all five alignments illustrates that north of the project, some areas have less erosion and some areas have accretion. Additionally, erosion around James Island due to WNW winds would essentially be eliminated by the construction of the alignments.

5.5.2 Specific Alignment 1 Sedimentation Affects

Non-cohesive Sediments

In construction of Alignment 1, the region along the west dike represents an area that is currently eroding and would become an accretion area. Results from construction of Alignment 1 for winds from the WNW shows that less erosion occurs for these winds, as the fetch length is less. The difference plot for WNW winds show reduced erosion of areas around James Island and near the northern tip of Taylors Island.

Cohesive Sediment

From the model, the difference plot for SSE winds illustrate that north of the project, some areas have less erosion and some areas have accretion.

5.5.3 Specific Alignment 2 Sedimentation Affects

Non-Cohesive Sediment

From the model, construction of Alignment 2 would provide the most protection to James Island from the long NNW wind fetch from across the Bay, preventing erosion in the lee of the project. Similar to Alignment 1, less erosion occurs from winds from the WNW, as the fetch length is much less. The difference plot for WNW winds shows reduced erosion of areas around James Island and near the northern tip of Taylors Island.

Cohesive Sediment

Results from the difference plot for SSE winds shows less erosion in addition to accretion north of the project, and decreased accretion east of the project. The area of impact is greater than for Alignment 1, although not to the same extent as for NNW winds.

5.5.4 Specific Alignment 3 Sedimentation Affects

Non-Cohesive Sediment

For NNW winds, the model predicts erosion would occur along the west dikes of the project site. For winds from the SSE, the currently eroding region along the west dike would become an accretion area. Model results from construction of Alignment 3 shows that less erosion occurs due to less fetch length, for WNW winds. Similar to the other two alignments, the difference plot of WNW winds shows reduced erosion of areas around James Island and near the northern tip of Taylors Island.

Cohesive Sediment

Modeling results for NNW winds shows a significant reduction in erosion in the project area following construction, and significantly more sediment accretion in the lee of the project, extending south to Taylors Island. Similar to Alignment 1, the model predicts a reduction in erosion for an area southeast of James Island.

5.5.5 Specific Alignment 4 Sedimentation Affects

Non-Cohesive Sediment

The model predicts that sedimentation changes due to construction of this alignment are similar to Alignments 2 and 5. The eroding region along the west dike would become an accretion area due to SSE winds. The SSE winds difference plot also predicts that accretion is reduced due to reduced erosion of the shallow areas and less sediment in the water column. The model predicts for WNW winds that construction of Alignment 4 produces less erosion, because the fetch length is much less.

Cohesive Sediment

The results for cohesive sediments are essentially the same as in the general sedimentation affects discussed in Section 5.5.1.

5.5.6 Specific Alignment 5 Sedimentation Affects

Non-Cohesive Sediment

Sedimentation changes for Alignment 5 are similar to Alignments 2 and 4. The results for WNW winds show that construction of Alignment 5 decreases erosion of areas around James Island and near the northern tip of Taylors Island.

Cohesive Sediment

The results for cohesive sediments are essentially the same as in the general sedimentation affects discussed in Section 5.5.1.

5.6 Conclusions

The Hydrodynamics and Sedimentation Modeling for the James Island Reconnaissance Study predicts that restoration of the island would possibly impact local conditions, especially in the area east and south of the island, and negligible impacts would be observed in the far field. The primary impacts on local conditions include substantial reduction of shoreline erosion along James Island and portions of Taylors Island and improved water quality within the region due to creation of a quiescent area east of the project.

5.6.1 Hydrodynamic Modeling Conclusions

The hydrodynamic model predicts minimal impacts on local tidal elevations, which would remain unchanged. Potential changes in tidal current velocities, coupled with wind induced wave conditions, could cause changes in sedimentation patterns and rates. Non-cohesive sands may exhibit reductions in both erosion and accretion rates following island creation. Decreased sedimentation of cohesive clays and decreased sediment movement east of James Island were predicted. Current velocities around the north of James Island increase on the order of 0.1 to 0.2 ft/sec, current velocities east of the project decrease by 0.4 to 0.5 ft/sec, and current velocities south of the project increase by about 0.4 to 0.5 ft/sec. Negligible changes are seen in water surface elevations.

5.6.2 Sedimentation Modeling Conclusions

The sedimentation model predicts that construction at James Island would have beneficial effects on sedimentation rates and patterns, with less erosion of the James Island shoreline and the shallow areas surrounding the remnant James Islands. Some protection would also be afforded to the shoreline of Taylors Island from wind and waves coming from the N, NNW, and NW directions. This decrease in erosion would likely cause reduced suspended sediment and improved water quality in the surrounding areas.

6.0 DREDGING AND SITE ENGINEERING

6.1 Introduction

A Dredging and Site Engineering Reconnaissance Study was conducted by GBA to summarize the dredging operations and site engineering aspects of restoring and developing habitat at James Island using dredged material. The full dredging and site engineering report, tables, and figures are included in Appendix D. This study presents five dike alignments that would provide tidal wetland and upland habitats at James Island. The habitat restoration project would be constructed with dredged materials removed from the Bay approach channels to Baltimore Harbor (east of North Point/Rock Point Line in the Patapsco River). The five alignments are analogous to the five alignments presented as part of the James Island Modification Conceptual Study, which was prepared for MES in 2001.

6.2 Purpose and Objective

The objective of this study was to conduct a Dredging Engineering Reconnaissance Study for the construction of the James Island habitat restoration project. This study presents details of the five alignments, including: the dike design, the construction and operation, and the associated costs needed to assist decision makers in selecting the site layout to be carried to the final design. The five alignments and dike cross-sections were developed based on consideration of coastal, environmental, geotechnical, and dredging and site engineering aspects and data.

The specific tasks conducted by GBA for this study and the five alignment layout options for the James Island site are included in Figure 3-1 of Appendix D.

For each of the five alignments, upland dike elevations of 10-ft MLLW and 20-ft MLLW were analyzed. Wetland and upland cells of equal ratios are being proposed as part of the restoration project. Wetland dike heights are 8 ft for all five alignments.

6.3 Site Design

Site surface areas were selected to minimize environmental impacts and to lie in waters less than −12 ft MLLW. The design total site footprints range between 979 and 2,202 acres. See Table 2-1 in Section 2.0 of this report. For the purposes of this study, the total surface areas are equally divided between upland and wetland habitat.

The total baseline perimeter ranged between 32,102 and 48,963 linear ft for the five alignments. The total baseline was the same for both the 10- and 20-ft upland dike elevation alternatives. This is due to the fact that the baseline perimeter was measured from the roadway on the dike crest and does not change for each alternative.

The neat dike-fill volumes for the 10-ft dike elevation were 2,733,000 to 3,578,000 cy and ranged between 4,505,000 and 5,844,000 cy for the 20-ft dike elevation alternatives for the five alignments. The neat fill volumes included allowances for backfill of excavated unsuitable materials.

Rock protection for the dikes was designed to yield sufficient protection against the adverse effects of high water and wave run-up resulting from a 35-year return period storm (Appendix D). Total rock quantities for these five alignments ranged between 455,000 and 872,000 tons. These quantities included toe armor, quarry run, slope armor, and slope underlayer stone.

For the 10-ft upland dike elevation alternative, the site capacity for the five alignments ranges between 23 and 52 mcy. For the 20-ft upland dike elevation alternative, the site capacity for the five alignments ranges between 35 and 79 mcy. The site operational life is estimated between 13 and 15 years for the five alignments with respect to the 10-ft dike elevation. The site operational life is estimated between 20 and 23 years for the five alignments with respect to the 20-ft dike elevation.

Estimated material pay quantities and site planning estimates and a summary of the site design characteristics are presented in Section 4 of Appendix D.

6.4 Site Construction

For the purpose of this report, it was assumed that the hydraulic stockpile and truck haul method of dike fill construction used for the PIERP would be used for the James Island project. It was assumed that a small hydraulic dredge would complete excavation and backfill of the unsuitable foundation material. It was also assumed that rock would be transported by barge to the site and then be handled by a crane at or near the dike section.

The total completion time was based on the time required for the longest construction element (rock placement for the 10-ft dike elevation and hydraulic fill for the 20-ft dike elevation) plus an additional six months to allow for mobilization, demobilization and overlap of the construction elements. Estimated total completion time was based on thirty working days per month at 12-hour days. It was also assumed that 15,000 cy of dike material would be dredged and stockpiled per day and 5,000 cy of dike material would be placed per day. Rock placement includes toe dike, slope stone and road stone. It was assumed that fifty linear ft of stone are placed per day.

Estimated construction completion times are presented in Table 5-1 of Appendix D.

This report assumes that, once the maintenance dredged material placed at the site approaches the elevation of the Bay water level, crust management would be implemented in order to maximize the operational life of the site. Also, dried crust resulting from such operations could be a valuable source for building berms and for future dike raising.

6.5 Total Site Costs

The total project costs, presented in constant 2002 dollars, for the operational life of the facility were generated as the sum of the initial construction costs, habitat development costs, site development costs, and the dredging, transport and placement costs. The total project costs are the summation of all the above referenced costs. These costs, along with the cost per cubic yard of capacity for the site, are presented to compare the five island alignments. The total costs of an alignment with a 10-ft MLLW dike elevation ranges from \$406 to \$759 million. The total costs of an alignment with a 20-ft MLLW dike elevation ranges from $591 million to $1.106 billion (See Table 6-1 of this report for cost ranges for different dike elevations). The costs related to the 10-ft upland dike elevation alternative and the costs related to the 20-ft upland dike elevation alternative are presented in Tables 6-1 and 6-2 of Appendix D.

6.6 Comparison of Option Costs

The baseline perimeter length, total surface area, and total site capacity were important factors in estimating the costs to construct and operate this site. Unit costs were determined by dividing the total cost by the site capacity. The site design and associated island project costs and unit cost for each of the five alignments with respect to the 10- and 20-ft MLLW dike elevations are presented in Table 7-1 of Appendix D. Annual dredging volumes from Baltimore Harbor Outer Channels and the C&D Approach Channel, requiring placement at this Island site is assumed to be on average 3.5 mcy. The dredging volumes include material from the following channels: (i) C&D Canal Approach, (ii) Tolchester Channel, (iii) Swan Point Channel, (iv) Brewerton Channel Extension, (v) Craighill Upper Range Channel (including Craighill Angle, Craighill Upper Range, and Cutoff Angle Channels). It should be noted that Alignments 1 and 3, for both the 10-ft dike and 20-ft dike, have net annual placements less than the 3.5 mcy average maintenance requirement for the approach channels to the Baltimore Harbor. In the case of Alignment 1, the net annual placement is 1.7 mcy. For Alignment 3, the net annual placement is 2.8 mcy. All other alignments have a net annual placement that meet the requirements of this project.

6.6.1 10-ft MLLW Dike Elevation

At the 10-ft MLLW dike elevation, Alignment 1 has the smallest total surface area (979 acres) and results in the lowest total cost ($406 million). Inversely, Alignment 2 has the second largest surface areas (2,127 acres) and has a total cost of $759 million. Alignments 2, 4 and 5 have similar surface areas that result in similar total costs ($709-759 million). The total project cost versus the total surface area for each alignment with respect to the 10-ft MLLW dike elevation design alternative is presented in Figure 7-1 of Appendix D.

Alignments 2, 4 and 5 have the smallest unit cost at $14/cy and $15/cy in comparison to Alignment 1, which has the largest unit cost at $18/cy. The unit cost per cubic yard of capacity versus the total surface area for each alignment with respect to the 10-ft MLLW dike elevation design alternative is presented in Figure 7-2 of Appendix D.

6.6.2 20-ft MLLW Dike Elevation

As with the 10-ft MLLW dike elevation, Alignment 1 has the smallest total surface area (979 acres) and results in the lowest total cost ($591 million). Inversely, Alignment 4 has the greatest surface area (2,202 acres) and has a total cost of ($1.106 billion). Alignments 2, 4 and 5 have similar surface area that results in similar total costs. The total project cost versus the total surface area for each alignment with respect to the 20-ft MLLW dike elevation design alternative is presented in Figure 7-3 of Appendix D.

Alignments 2, 4 and 5 have the smallest unit cost at $14/cy in comparison to Alignment 1 that has the largest unit cost at $17/cy due to size and depth of the alignment. The unit cost per cubic yard of capacity versus the total surface area for each alignment with respect to the 20-ft MLLW dike elevation design alternative is presented in Figure 7-4 of Appendix D.

TABLE 6-1. SUMMARY OF SITE COSTS FOR FIVE PROPOSED ALIGNMENTS FOR JAMES ISLAND

Alignment Number	Total site capacity (mcy)	Total site life (yr)	Project costs ($ millions)			Cost per cy capacity ($/cy)
			James Island	Channel projects	Total project costs	
10 Ft. MLLW Dike Elevation						
1	23	13	308	99	406	18
2	52	15	531	227	759	15
3	37	13	430	164	594	16
4	51	15	526	225	751	15
5	49	14	494	214	709	14
20 Ft. MLLW Dike Elevation						
1	35	20	439	152	591	17
2	78	22	759	342	1,101	14
3	57	20	611	250	861	15
4	79	23	762	344	1,106	14
5	75	21	724	326	1,050	14

7.0 ENVIRONMENTAL CONDITIONS

The existing conditions of natural resources on and adjacent to James Island have been evaluated in two separate investigations. MES conducted a conceptual/reconnaissance level environmental study relating to the construction of the habitat restoration at James Island. This reconnaissance level study included reviews of readily available literature, on-line data, and a site visit on June 26, 2001 to document and assess potential impacts of the habitat restoration project to the existing natural resources surrounding and including James Island. The full MES reconnaissance report, tables, and figures for the two seasons of sampling are included in Appendix E. Site-specific seasonal data for some resources of regional concern were collected by EA. The full environmental conditions report, tables, and figures are included in Appendix F. For the purposes of this summary, the first two seasons of data on the existing conditions of the island and surrounding waters are being used to augment the information collected by MES. Seasonal surveys of terrestrial resources were conducted to document wildlife and avian utilization and major vegetative communities. Aquatic investigations included sediment and *in situ* water quality, benthic collections and analysis, fisheries studies, plankton collections, and SAV mapping. This section summarizes the results of the MES investigations and the EA field collection efforts for Fall (October and November) 2001 and Summer (June) 2002. Sampling was conducted within and adjacent to the proposed footprints of the proposed project and on and adjacent to the three island remnants (northern, middle, and southern remnants). Details concerning the components of the investigation and the sampling season and year are presented in Table 7-1 below.

TABLE 7-1. COMPONENTS, SEASON, AND YEAR OF FIELD SAMPLING CONDUCTED AT JAMES ISLAND

Type of Study	Season and Year of Study	
	Fall 2001	Summer 2002
Wildlife and Avian Observations	√	√
Sediment Quality	√	
In Situ Water Quality	√	√
Benthic Collections	√	√
Timed Bird Observations		√
Fisheries Studies (trawl & seine collections)		√
Plankton Collections		√
Submerged Aquatic Vegetation (SAV) Mapping		√

7.1 Existing Conditions and Habitat Description

James Island has a humid, continental climate. The island is currently comprised of three narrow remnants that are located slightly east of true north in the mouth of the Little Choptank River. The Little Choptank River is a tidal creek, fed by relatively little freshwater inflow. James Island is located in the central portion of the Chesapeake Bay where the salinity level can be classified as mesohaline. The salinity in the general area surrounding James Island is 10.8 to 16.8 parts per thousand (ppt), based on two seasons of sampling (See Table 3-7 in Appendix F). An analysis of the bathymetry shows that water depths within the proposed project area vary between –2 and –12 ft MLLW. The average tidal amplitude is 1.3 ft. Substrates throughout the project area are predominantly fine sands with some mud/clay. On the western side of the island remnants, the bottom is fairly flat and homogenous, while the eastern side has areas of variable depth due to clay shelves. Submerged habitat features include downed trees in the waters immediately adjacent to the shorelines. SAV was observed as three individual areas along the eastern shoreline of the northern, middle, and southern remnant islands; no SAV was present within the proposed concept areas. The existing beds were predominantly composed of widgeon grass of low to moderate density.

In general, the three island remnant shorelines consist primarily of fringe marshes and forested areas ending in steep, eroding banks. The northern and western shorelines of each remnant show the most severe erosion. There are also many downed trees in the adjacent waters due to erosion of the upland areas. The northernmost remnant is the largest of the three and is subjected to the harshest natural physical forces. The shoreline of the northern portion of this remnant has the steepest eroding banks, with heights between 5 to 10 ft, and numerous fallen trees lie along the shoreline and in the adjacent waters. The northern and middle remnants are joined by a sandy beach spit that terminates into high-low marsh complexes on each end. Mixed forest stands of loblolly pine dominate the interior of all three remnants. Small areas of high marsh can be found on all three remnants and the southern remnant has a fairly extensive marsh complex in the center. The middle remnant appears primarily wooded and is the smallest of the three remnants. The western side of the middle remnant has eroded banks with elevations of 5 to 10 ft lined with fallen and submerged snags similar to the northern remnant. The southern remnant is dominated by wooded areas mixed with fringe marsh habitat and is separated from the middle remnant by a tidal gut. There is also evidence that a recent fire scorched and killed trees and impacted some of the marsh areas on the northern and southern remnants.

7.1.1 Water Quality

The water quality conditions in the vicinity of James Island are typical of mesohaline reaches of the Bay. Long-term monitoring of *in situ* water quality and nutrients near the mouth of the Little Choptank River indicate typical seasonal temperatures and dissolved oxygen concentrations consistent with shallow, well-mixed areas of the Bay. Salinity varied within and between the years represented, but could be attributed to fluctuations in precipitation and in freshwater flowing out of the Little Choptank. The data for chlorophyll-*a* and monitored nutrients did not exhibit marked seasonal patterns and there was no evidence of eutrophication (MES 2002).

James Island *in situ* water quality measurements were obtained in the field during the Fall 2001 and Summer 2002 surveys at five of the ten benthic sampling stations (stations JAM-002, JAM-005, JAM-007, JAM-009, and JAM–010). Depths in the areas sampled (other than at the seine stations) ranged from 4 to 13 ft (Figure 2-1). Salinities over both seasons ranged from 10.8 to 16.8 ppt. This is typical (although 10.8 ppt is somewhat low) for this reach of the Chesapeake Bay. Turbidity was low at all locations but somewhat elevated along the shoreline (seine stations), which is expected. Temperatures were consistent with the expected norms for fall

(13.6 to 18.6 °C) and summer (24.1 to 26.9 °C) and pH was typical of waters of this salinity regime. Dissolved oxygen (DO) readings were slightly out of range for the expected norms of shallow, well-mixed waters of the Bay at these salinities and temperatures. Fall readings between 10.2 and 12.9 mg/L are a bit high. The readings over 13 mg/L are anomalous and reflect a membrane tear over the DO probe. The oxygen readings taken at the seine stations range 5.9 to 8.5 mg/ L and most otter trawl stations (ranges from 4.7 to 8.1 mg/L) are within the range expected at these temperatures, salinities and depths. There was one low (and probably anomalous) reading taken at one bottom trawl station (JF-003). All oxygen readings taken in June 2002 are lower than expected and reflect a meter malfunction due to a membrane tear over the DO probe during benthic and plankton sampling.

7.1.2 Sediment Quality

The Chesapeake Bay is located in the Atlantic Coastal Plain Physiographic Province and is underlain by sequences of clay, silt, sand, and gravel. Sediments in the vicinity of James Island would be expected to be a mix of sand, silt, and clay. Due to the erosion of the island, the soils of James Island are likely to be found in varying degrees as a veneer over historical bottom sediments in the waters around the island, where they haven't been swept away by natural forces. A complete description of the soils is included in Section 3 of Appendix E. The silt and high clay concentration features of the Honga, Elkton, Keyport, and Sunken soils of James Island are expected to be found in the adjacent shallows.

Fall 2001 sediment quality sampling at James Island consisted of physical and chemical characterization of the bulk sediment quality measurements from the same five benthic stations as *in situ* water quality (See Section 2 of Appendix F for details of sediment quality and chemical and physical analyses) (Figure 7-1).

Results of the physical analyses indicated that the sediment around James Island was predominately comprised of sand at all locations except JAM-010, which was predominately comprised of silt-clay. Of the five James Island sediment samples, location JAM-007 had the highest proportion of sand, although both stations JAM-002 and JAM-005 also had high proportions of sand. Details of the physical analyses are included in Section 3 of Appendix F.

Of the 155 chemical constituents tested in the sediment, 57 were detected in James Island sediments. The majority of these detected constituents were found in low concentrations, and were representative of background concentrations. SVOCs, VOCs, and organophosphorus pesticides were not detected in any of the sediment samples.

Concentrations of detected analytes in sediment samples were compared to Sediment Quality Guidelines (SQGs) for marine sediments (Buchman 1999) to assess the sediment quality of the existing materials within and adjacent to the proposed project area. SQGs are used to identify potential adverse biological effects associated with contaminated sediments. Probable Effects Levels (PELs) and Threshold Effects Levels (TELs) are biological effects-based SQGs that have been applied to contaminated sediments in Florida and other areas of the southeastern United

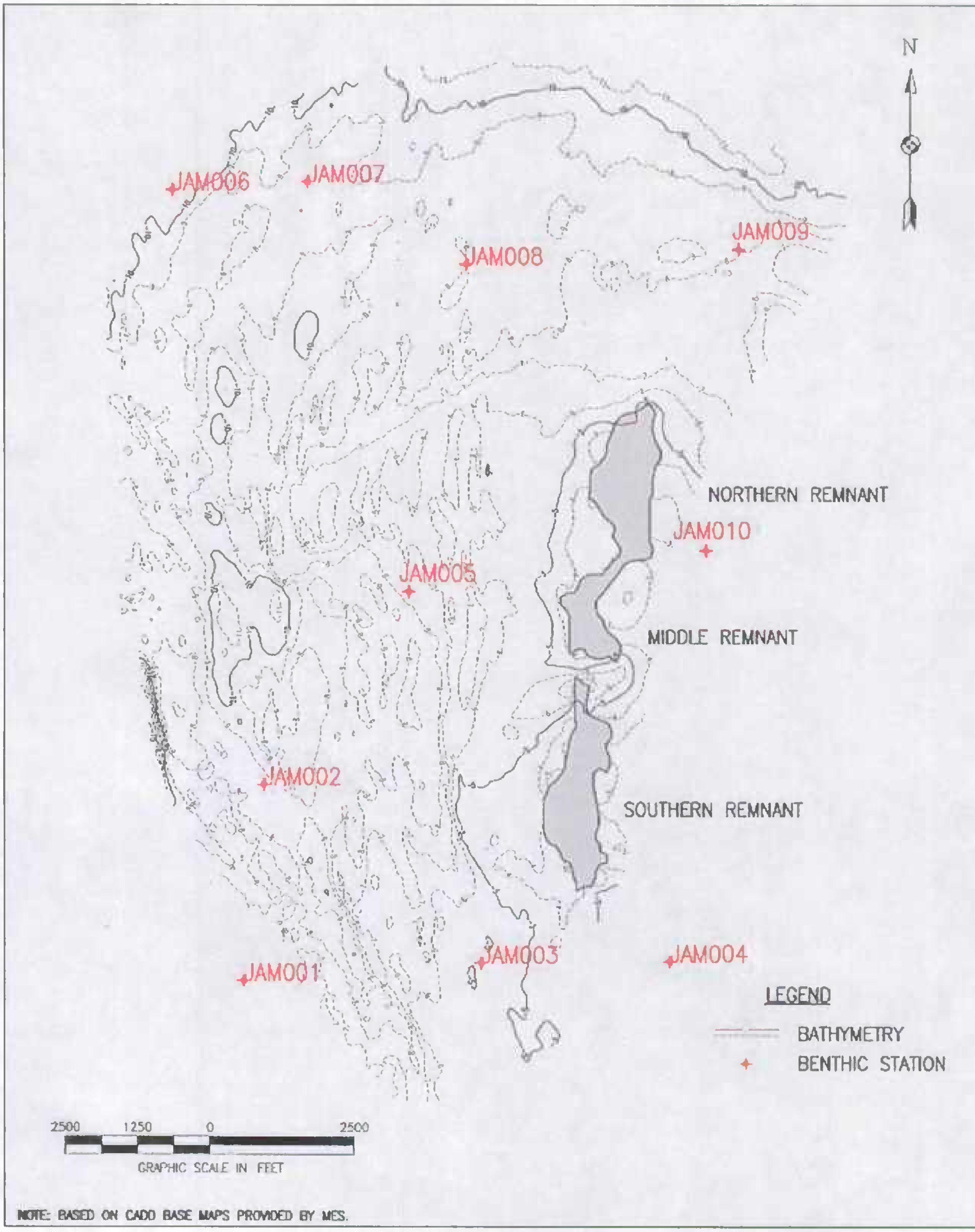

Figure 7-1. Benthic Stations in the Vicinity of James Island, June 2002

States (Buchman 1999; MacDonald et al. 1996). TELs represent contaminant concentrations below which adverse biological effects rarely occur. PELs represent contaminant concentrations above which adverse biological effects frequently occur. One PAH, acenaphthylene, exceeded the TEL value at sampling location JAM-002 by a factor of approximately 2.6 but did not exceed PEL values. None of the other detected chemical constituents exceeded TEL values.

7.1.3 Fisheries and Aquatic Life

Many finfish and shellfish species support valuable commercial and recreational fisheries in the Chesapeake Bay. The Bay also supports a diverse fish community beyond those recognized as commercial or recreational resources. A list of species expected to occur in mesohaline reaches of the Bay is included in Table 6-3 of Appendix E. Site-specific fisheries and aquatic sampling took place in the vicinity of James Island in Summer 2002. Two sampling techniques, bottom trawl and beach seining, were employed to collect adult and juvenile fish species. See Figure 7-2 for trawling station locations and Figure 7-3 for seining station locations. Four areas of the shore zone around James Island were sampled using a beach seine. In addition, six areas inside and outside of the proposed alignments were sampled using a bottom trawl.

A total of twenty species, representing fifteen families, were collected during the Summer 2002 sampling. A summary of the numbers and sizes of all organisms collected is summarized by gear types in Table C-5 of Appendix F. All of the fish collected in Summer 2002 were typical of species that occur in mesohaline reaches of the Chesapeake Bay. Based upon the lengths of the fish collected, the seine yielded predominantly juveniles of most species. This is typical of the gear used and indicates that the shore areas of James Island are providing nursery habitat for many species. There did not appear to be a significant difference in collections that were made inside and outside the SAV beds with this gear. Although the otter trawls yielded fewer individuals, most were larger (adult or subadults) of species that are associated with the bottom. The lack of diversity in the trawl collections is probably a result of the lack of diversity of bottom types in the area that were trawled. It is very likely that these areas are used for foraging but there are no other habitat features that would cause fish to linger.

Essential Fish Habitat (EFH)

James Island is located in an area that may provide EFH to nine species that are managed under the Magnuson Stevens Fisheries Conservation Act: summer flounder (*Paralicthys dentatus*), windowpane flounder (*Scopthalmus aquosus*), bluefish (*Pomatomus saltatrix*), cobia (*Rachycentron canadum*), red drum (*Sciaenops ocellatus*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), Atlantic butterfish (*Perprilus triacanthus*), and black sea bass *(Centropristus striata)*. Consultations with the National Marine Fisheries Service (NMFS) have indicated that three species, bluefish, summer flounder, and red drum, would be the species of particular concern at James Island (Nichols 2002).

During the Summer 2002 fisheries and aquatic sampling, two of the potential fish species (summer flounder and red drum) were collected. The waters around the island remnants are supporting a variety of forage species that are known to be important food sources for the species of concern. Because SAV occurs adjacent to many of the remnants, James Island may also be

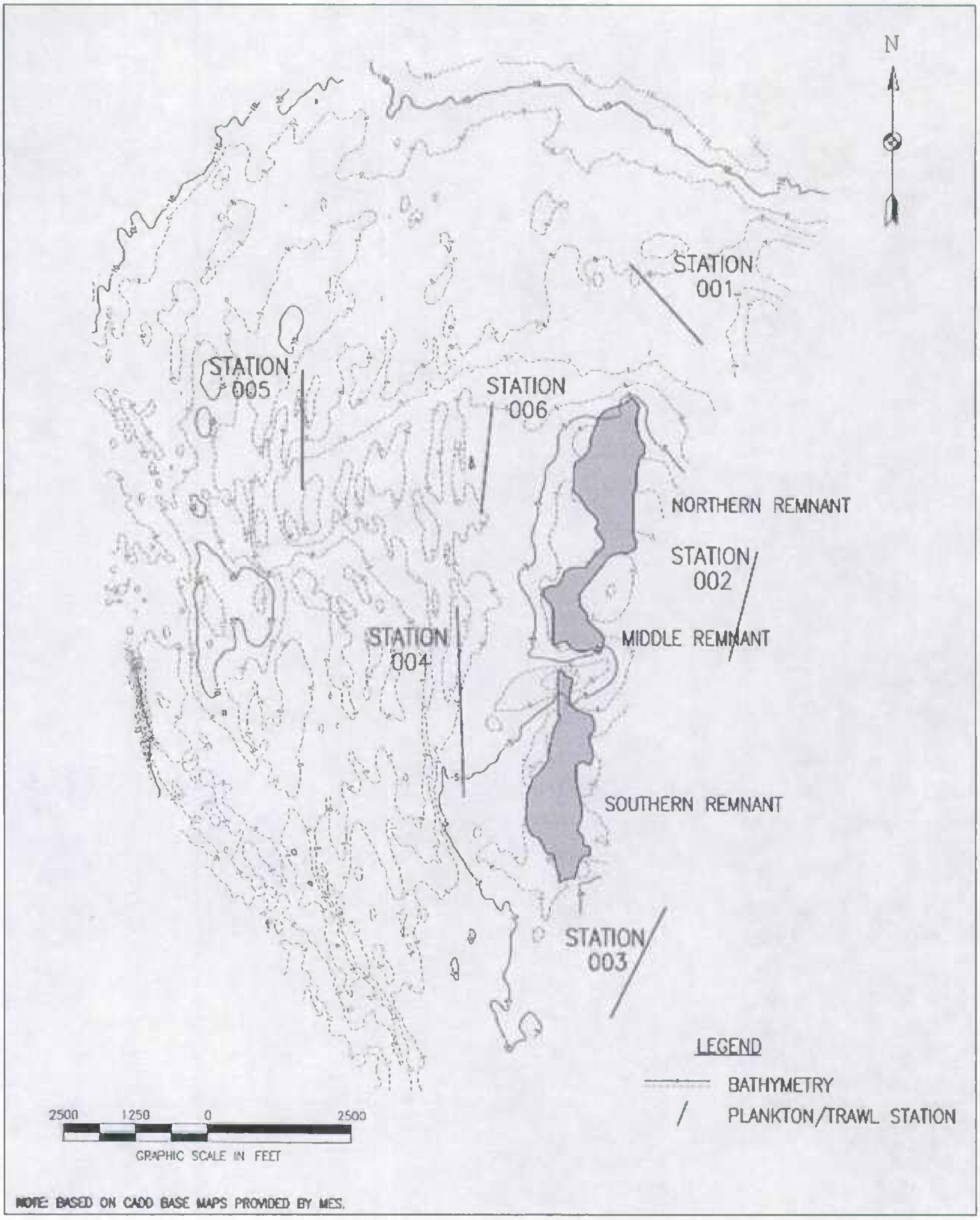

Figure 7-2. Plankton/Trawl Stations in the Vicinity of James Island, June 2002

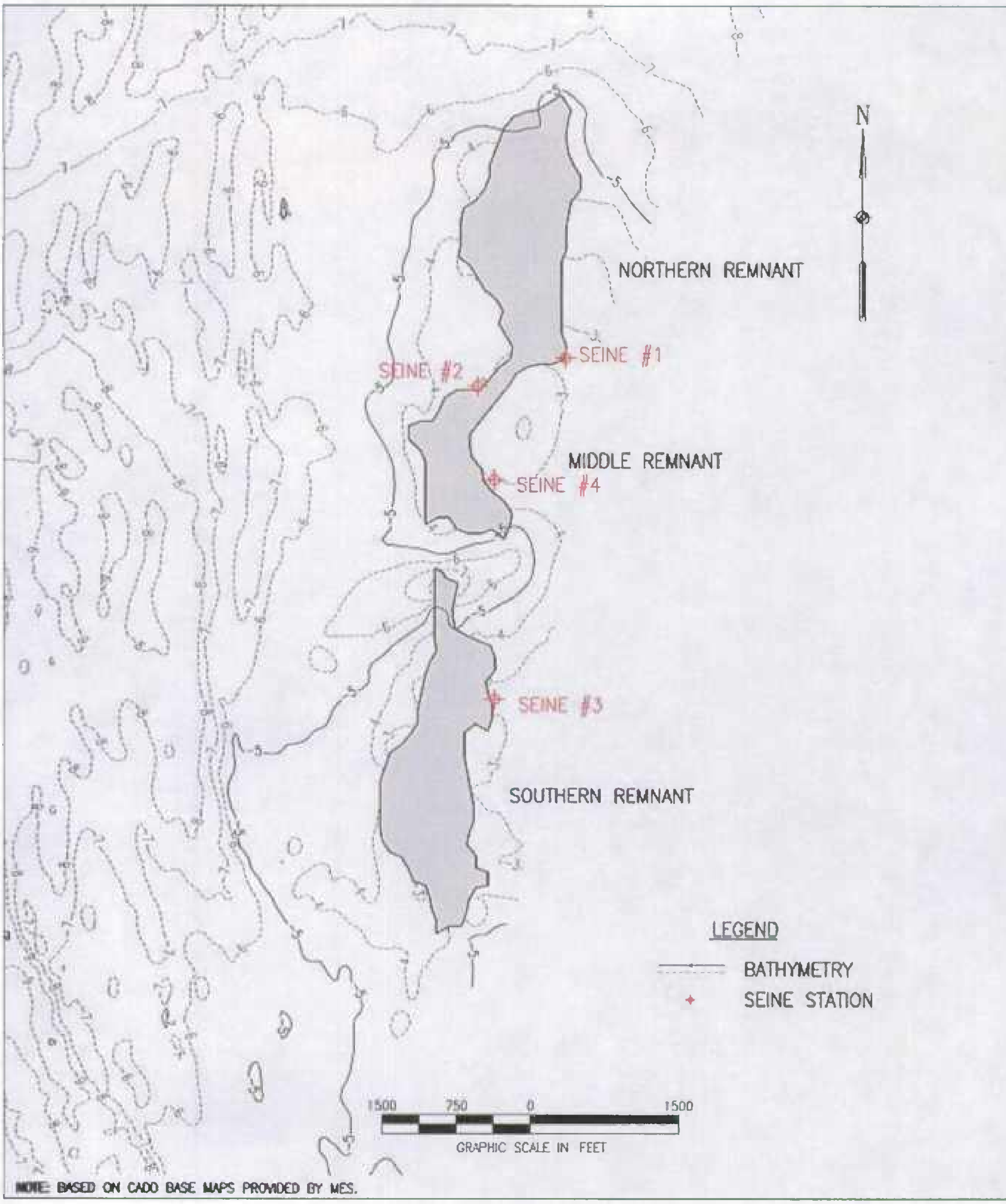

Figure 7-3. Seine Locations on James Island, June 2002

providing Habitat of Particular Concern (HAPC) for summer flounder and red drum. Consultation with NMFS on this issue is ongoing.

Benthos

The Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI) was used to evaluate the benthic community (Weisberg et al. 1997). The metrics were designed to characterize the response of the benthic community to stresses. The B-IBI is an extension of an effort used to establish benthic restoration goals for the Chesapeake Bay and involves scoring each metric as 5, 3, or 1, depending on whether its value at a site approximates, deviates slightly, or deviates greatly from conditions at reference sites. The Chesapeake Bay Restoration Goal Index (RGI) value of 3 represents the minimum restoration goal, for a well-balanced benthic community. The RGI values of less than 3 are indicative of a stressed community and values of three or more indicate habitats that meet or exceed the restoration goals. The B-IBI methodology is detailed in Section 2 of Appendix F.

The MDNR benthic monitoring program sampled two randomly selected sites in the vicinity of James Island in 1999 and 2000, respectively. The 1999 site is located in the shallows off of the northeast site of the northern remnant, and the 2000 site is located in approximately 15 ft of water 1¼ mile northeast of James Island. The 1999 sample (obtained from the shallows to the northeast) received a score of 2.33 on the B-IBI, ranking the sample site as degraded because values of 3 have not met the RGI and indicate a stressed community. The year 2000 sample also received a score ranking the site as degraded (between 2.1 and 2.6), but the exact B-IBI score was not available for that year. Low scores on these recent B-IBI tests indicate a limited benthic community in the sediments around the island.

Site-specific benthic sampling was conducted at 10 locations surrounding James Island in Fall 2001 and Summer 2002 (Figure 7-1). A B-IBI score was calculated for each site (See Table 7-2). Four additional metrics were selected to further characterize the benthic community. These include total number of taxa, evenness, species richness, and diversity.

Overall, the B-IBI metric calculations were low at stations collected near the island. A summary of the B-IBI scores for the Fall 2001 and Summer 2002 benthic collection at James Island is presented in Table 7-2. The Fall 2001 sampling total B-IBI scores were low for all stations sampled except for JAM-010, which had a total B-IBI score of 3.0. This was the only station sampled in Fall 2001 to meet the Chesapeake Bay RGI value of 3 as the minimum restoration goal. The Summer 2002 sampling total B-IBI scores were low for all ten stations and none of the stations sampled in Summer 2002 met the Chesapeake Bay RGI. The mean Fall 2001 total B-IBI score for the combined sites was 1.8 and the Summer 2002 mean total B-IBI score for the combined sites was 1.6, both corresponding to low scores which generally confirms the earlier State findings. Species abundance was high in both the Fall 2001 and Summer 2002 collection. Bivalvia were the most dominant group found at all benthic stations, with the dominant bivalve being the gem clam. The Shannon-Weiner Diversity results from the Fall 2001 and Summer 2002 sampling corresponded to low diversity. The abundance of carnivore/omnivore taxa was low at all stations except for JAM-010 for the Fall 2001 sampling and low at all stations for the Summer 2002

TABLE 7-2. SUMMARY OF B-IBI SCORES BY STATION NUMBER AT JAMES ISLAND FOR FALL 2001 AND SUMMER 2002 BENTHIC SAMPLING

Type of Metric	Benthic Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004[c]	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010[c]
B-IBI Scores for Fall 2001										
Abundance ($\#/m^2$)[a]	1	1	1	1	1	1	1	1	1	3
Shannon-Weiner Diversity[a][b]	1	1	1	1	1	1	1	1	1	1
Stress-Sensitive Taxa Abundance (%)	1	1	1	--	1	1	1	1	1	--
Stress –Indicative Taxa Abundance (%)	5	5	5	--	5	5	5	5	5	--
Carnivore/Omnivore Abundance (%)	1	1	1	1	1	1	1	1	1	5
B-IBI[d]	1.8	1.8	1.8	1	1.8	1.8	1.8	1.8	1.8	3
B-IBI Scores for Summer 2002										
Abundance ($\#/m^2$)[a]	1	1	1	1	1	1	1	1	1	1
Shannon-Weiner Diversity[a][b]	1	1	1	1	1	1	1	1	1	1
Stress-Sensitive Taxa Abundance (%)	1	1	1	--	1	1	1	1	1	--
Stress –Indicative Taxa Abundance (%)	5	5	5	--	5	5	5	5	5	--
Carnivore/Omnivore Abundance (%)	1	1	1	1	1	1	1	1	1	1
B-IBI[d]	1.8	1.8	1.8	1	1.8	1.8	1.8	1.8	1.8	1

(a) Includes all species collected.
(b) Log used was log base e
(c) JAM-004 and JAM-010 are classified as high mesohaline mud; therefore, stress-sensitive taxa abundance and stress-indicative taxa abundance were not included in the calculation of the B-IBI.
(d) Mean of metric scores

sampling. See Section 3 of Appendix F for details concerning the benthic community metrics results.

Plankton

Plankton sampling was conducted during Summer 2002 at six locations, utilizing the same basic stations as the fisheries bottom trawl locations (Figure 7-2). Results of plankton sampling are included in Section 3 of Appendix F. Eggs of four fish species were found in the plankton in the vicinity of James Island and include the bay anchovy, naked goby (*Gobiosoma bosci*), weakfish (*Cynoscion regalis*), and hogchoker (*Trinectes maculatus*). Fish egg collections were dominated numerically by bay anchovy eggs. Bay anchovy egg density was somewhat higher than expected, and this was likely due to cold, spring water conditions that could have prompted the adults to delay their first spawn until early June. Seven species of larval fish were identified in the plankton and included Atlantic silverside (*Menidia menidia)*, bay anchovy, blenny species (*Blenniidae* spp.), naked goby, northern pipefish (*Sygnathus fuscus*), seahorse (*Hippocampus erectus*), and skilletfish (*Gobiesox strumosus*). No larval form of any species dominated the plankton over all stations and depths. The fish eggs and larvae that were collected in the plankton in Summer 2002 were typical of this reach of the Bay in summer. The relatively high densities of some species indicate that the waters surrounding the island remnants are providing relatively good fish habitat, which is consistent with the results of the seine investigation.

The macroinvertebrates found in the plankton near the remnants included crab zoea, shrimp larvae, Amphipoda, Isopoda, Polychaeta, Syngnathidae, and Nematoda. Crab zoea numerically dominated collections at most stations at both the surface and bottom, although shrimp larvae and amphipods were very abundant in some places as well. Zooplankton distributions showed a clear trend of higher overall densities at the bottom at most sampling stations. This is consistent with zooplankton diel trends. The plankton found are typical of those found in the shallows throughout mesohaline portions of the Bay and are helping to support the fisheries community near the island and in adjacent areas of the Bay.

7.1.4 Submerged Aquatic Vegetation (SAV) and Shallow Water Habitat

SAV data for James Island was downloaded from the Virginia Institute of Marine Science (VIMS) website. The data included VIMS SAV mapping for the entire Bay interpreted from annual overflights. The period of record for this data was from 1971 to 2000 and resulted in 22 years of data; not all years were flown during the period of record (See Section 6 of Appendix E). Data for 2001 and 2002 were not available at the time that this report was prepared. The available data were superimposed on maps of the area and compared to the proposed alignments for the James Island restoration project. Mapping of the existing VIMS SAV overflight data in the vicinity of James Island revealed that SAV was apparent adjacent to the island remnants in six years. The six years included 1989, 1990, 1991, 1992, 1993, and 1999. The data from these years have been downloaded, printed, and are presented in Figures E-1 through E-6 of Appendix F. Table 7-3 summarizes the areas of SAV of the beds immediately adjacent to James Island from 1971 to 2000. In addition to the acreages, the outside perimeter of the beds has been calculated in an attempt to estimate the summer flounder foraging habitat area. SAV covered an area of one to 18 acres in the years it was present, with perimeter (fringe habitat) lengths of 776.5

to 4,803.8 ft. The acreages reflected in Table 7-3 are for total SAV distributions in the area, however, no SAV has occurred within any of the proposed dike alignments since 1971.

Ground-truthing of the overflight data was conducted by the Environmental Protection Agency (EPA), which found two SAV beds adjacent to the eastern side of James Island that are reported on the 1999 VIMS map. The beds were of low to moderate density and dominated by widgeon grass *(Ruppia maritima).*

SAV beds were observed on the eastern side of the island during the MES June 2001 site investigation; these beds were identified as eelgrass *(Zostera marina)* and appeared to be low in density, and were present along the entire eastern shorelines of the sandy neck and most of the northern remnant. EA observations from the Fall 2001 indicated that no SAV was present within the proposed concept areas, but most of the eastern shorelines of the remnants were supporting SAV beds of varying densities. The existing areas of SAV were mapped in more detail during the Summer 2002 field surveys. The areas of SAV mapped are illustrated in Figure 7-4. Widgeon grass was the dominant SAV species identified in the beds and three individual areas of widgeon grass were located along the eastern shoreline of the island remnants. The SAV beds ranged from 100 to 150 yards from the eastern shoreline of the northern, middle, and southern remnants. In addition, small pockets of sea lettuce (*Ulva lactuca*), which is considered a macroalgae and not a true SAV, were located in one of the beds of widgeon grass.

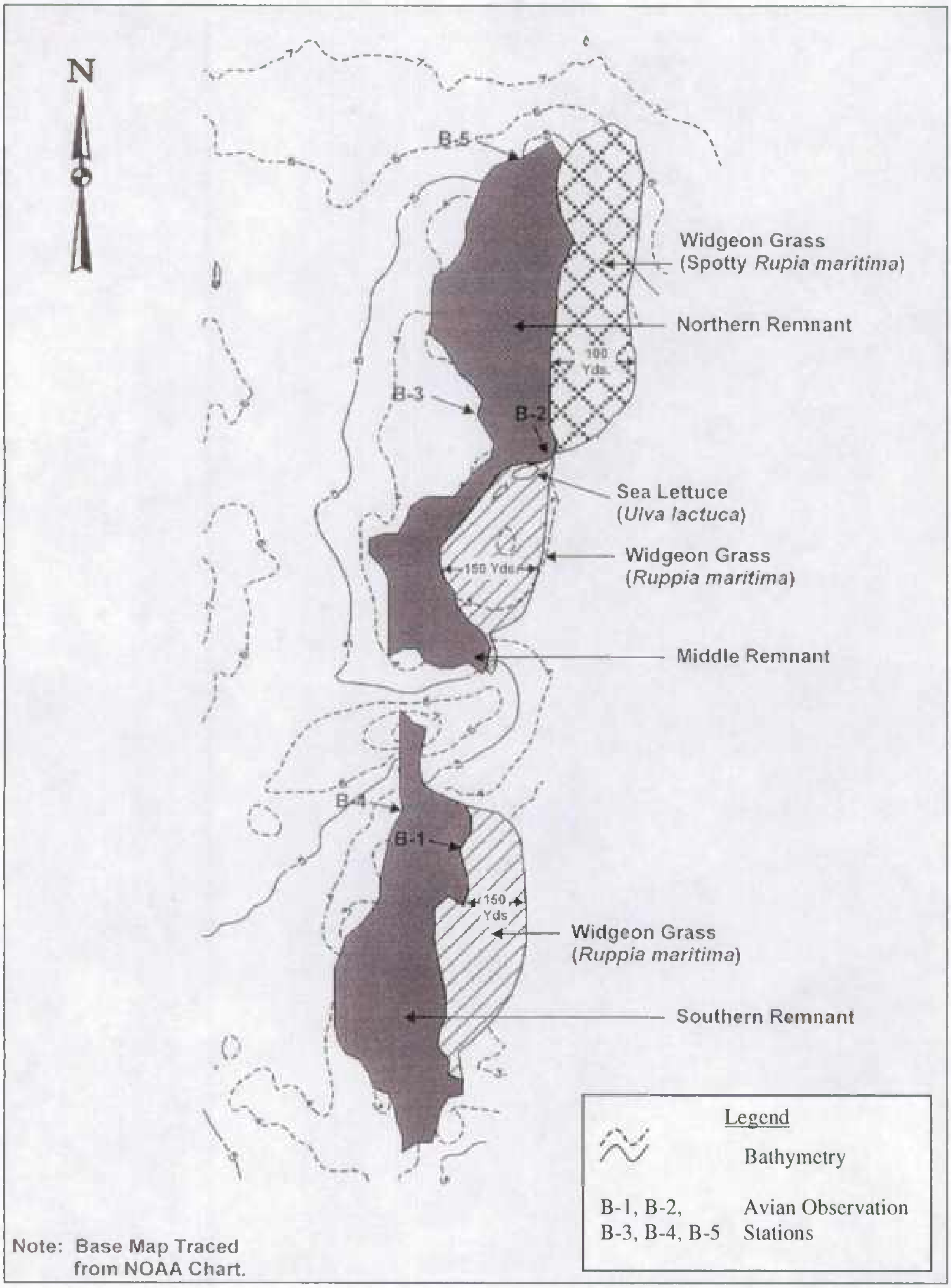

Figure 7-4. Avian Observation Stations and Extent of SAV on James Island, June 2002

TABLE 7-3. EXTENT OF HISTORICAL SUBMERGED AQUATIC VEGETATION (SAV) IN THE VICINITY OF JAMES ISLAND AS DETERMINED BY VIRGINIA INSTITUTE OF MARINE SCIENCES (VIMS)

Year of SAV Survey	Acres of SAV*	Perimeter (ft) of SAV*
1971	0.0	0.0
1972	Area not flown during this year	
1973	Area not flown during this year	
1974	0.0	0.0
1975	Area not flown during this year	
1976	Area not flown during this year	
1977	Area not flown during this year	
1978	0.0	0.0
1979	0.0	0.0
1980	0.0	0.0
1981	0.0	0.0
1982	Area not flown during this year	
1983	Area not flown during this year	
1984	0.0	0.0
1985	0.0	0.0
1986	0.0	0.0
1987	0.0	0.0
1988	Area not flown during this year	
1989	1.0	776.5
1990	12.1	4198.0
1991	5.6	3414.4
1992	10.0	3633.6
1993	12.1	2834.9
1994	0.0	0.0
1995	0.0	0.0
1996	0.0	0.0
1997	0.0	0.0
1998	0.0	0.0
1999	18.1	4803.8
2000	0.0	0.0
2001	Data not available	
2002	Data not available	

*0.0 = no viable SAV observed in vicinity of James Island

7.1.5 Terrestrial Vegetation and Wetlands

Vegetative communities and habitat types observed at James Island in Fall 2001 and Summer 2002 were categorized by field reconnaissance activities and the documentation of data during field activities to the three island remnants (See Appendix F). Additionally, aerial photographs, maps, and field notes from previous investigations were used to determine the community types present at the island.

The northern, middle, and southern remnants were occupied by high and low marsh areas, upland forest areas, open water habitats, sandy beaches, and pockets of SAV (Figure 7-5). All of the remnants are eroding (particularly along the northern and western shorelines) which is resulting in bare ground, fallen trees, and compromised marshes. This is exacerbated in some areas due to a fire that has killed vegetation in the northern and southern remnants. The low marsh areas are dominated by saltmarsh cordgrass (*Spartina alterniflora*) and the high marsh areas are dominated by saltmeadow cordgrass (*Spartina patens*) interspersed with saltgrass (*Distichlis spicata*) and the dominant shrub, marsh elder (*Iva frutescens*). The low marsh areas were often associated around the island remnants in a fringe fashion. Upland forest areas were evident in the central portions of all three island remnants and are dominated by almost monotypic stands of Loblolly pine, although deciduous plant species including sycamore (*Platanus occidentalis*) and willow oak (*Quercus phellos*) also inhabit the upland areas. The majority of the wooded portions of the island remnants appear to be relatively mature and evidence of past fires on the island was observed. Specific descriptions of the vegetation observed on each remnant can be found in Section 3 of Appendix F.

7.1.6 Avian and Other Wildlife Observations

Avian and wildlife observations were made during MES visits to the island in June 2001 (Section 3 of Appendix E) and during the EA visits in Fall 2001 and Summer 2002 (Section 6 of Appendix F). Avian station locations where observations were recorded in Summer 2002 are included in Figure 7-4. Wildlife and wildlife signs (e.g., tracks, scat, bones, etc.) encountered were noted and are included in Section 3 of Appendix F. Evidence of utilization by horseshoe crabs (*Limulus polyphemus*) fiddler crabs (*Uca pugnax*), blue crabs (*Callinectes sapidus*), cownosed rays (*Rhinoptera bonasus*), Atlantic croakers (*Micropogonias undulatus*), diamond-backed terrapins (*Malaclemys terrapin*), northern water snakes (*Nerodia sipedon*), and garter snakes (*Thamnophis sirtalis*) were found by EA scientists. Sika deer *(Cervus nippon*) were introduced to James Island in the 1930's and tracks were noted during all site visits. Other mammals, including the raccoon (*Procyon lotor*), were identified by their tracks as seen in the sand and clay areas. Shells of the Atlantic ribbed mussel (*Geukenisa demissa*), American oyster *(Crassostrea virginica*), razor clams *(Tagelus plebius*), and soft-shell clams (*Mya arenaria*) were also found along the beach (spit) in Fall 2001.

Avian Observations

Timed bird survey observations were made during Summer 2002 at five stations around the perimeter of the three remnants (See Table 3-15 of Appendix F). At each station all avian species heard and/or observed with binoculars during the 15-minute period and within 180-degrees were recorded on data sheets. In addition to the timed avian observations, incidental bird species

Figure 7-5. Location of marshes on James Island

observed were noted during the James Island habitat characterization surveys in both Fall 2001 and Summer 2002.

A total of 42 species of birds were identified during visits to the island in Fall 2001 and Summer 2002 (See Table 3-14 of Appendix F. All species were typical of this area of the Bay although both the Fall 2001 and Summer 2002 observations seemed to be made after the intensive spring and fall migrations through the area.

7.1.7 Rare, Threatened, and Endangered Species

The bald eagle (*Haliaeetus leucocephalus*) is a Federal and Maryland State-listed threatened species. The bald eagle was observed in the vicinity of the remnants in Fall 2001 and also during the site visits in Summer 2002. Observations included an active bald eagle nest on the middle remnant containing an immature bird near fledging stage. In addition to the immature bird still in the nest, several adults and immature bald eagles were seen in the Summer 2002 survey usually perched in loblolly pines, on dead snags, or flying along the edges of all three remnants. One carcass of an adult bald eagle was found on the southern remnant during the Summer 2002 site visit; it was unclear when or how the bald eagle died.

Additionally, several other avian species identified at James Island during the Fall 2002 surveys have conservation status determinations. These determinations were made either by the U.S. Fish and Wildlife Service's Office of Endangered Species in accordance with the Endangered Species Act (bald eagle), or by the Maryland Department of Natural Resources in accordance with the Non-game and Endangered Species Conservation Act (royal tern). The bald eagle, a federal and state-listed threatened species is a documented breeding species in the Chesapeake Bay region, including Dorchester County. An active nest was documented on James Island in June 2002 during a previous site visit. Several other species observed on James Island during the Fall 2001 and Summer 2002 survey are also listed as rare, threatened, and endangered (RTE) animals of Maryland prepared by the Maryland Wildlife and Heritage Division (Heritage) of the Department of Natural Resources. Brown pelican, double-crested cormorant, and northern harrier are all Heritage-listed species, however, the Maryland list of RTE species is based on the rarity of the species based on their breeding status (DNR 2002). The brown pelican, double-crested cormorant, and northern harrier are all known breeding bird species in Dorchester County (Illif et. al. 1996).

Recently, the U.S. Fish and Wildlife Service (USFWS) and the NMFS have cited the shortnose sturgeon *(Acipenser brevirostrum)*, a Federally-listed endangered species, as a concern within the Bay. USFWS also has expressed concerns about the wild Atlantic sturgeon *(Acipenser oxyrhynchus)*, which has been recorded in the Bay as a species of concern but is not listed as federally endangered. In 1996, USFWS initiated a Reward Program for incidental catches of sturgeon in commercial gear. Data for 1996 through March 2002 provided by MDNR reports no shortnose sturgeon catches within 3.5 miles of James Island. The same MDNR data reports five catches of Atlantic Sturgeon in the vicinity of the island: two catches approximately 0.7 and 2.0 miles east of the island, respectively; one catch approximately 2.5 miles northwest of the island; and two approximately 2.5 and 3.5 miles west of the island. No reported Atlantic sturgeon catches were within any of the proposed alignments. Consultations with MDNR, USFWS, and NMFS are ongoing.

7.1.8 Commercial Fishery

The Chesapeake Bay and Little Choptank River support commercial fishing for oysters, soft-shell clams, blue crabs, and finfish. The NOAA and the MDNR have separated the Chesapeake Bay into zones and maintain catch statistics for commercial fisheries in each zone. The statistics for the James Island area are included in Tables 6.4 and 6.5 of Appendix E. Specific information for the most commercially important species in the vicinity of James Island is detailed below.

Oysters
Three NOBs are located in the vicinity of James Island (Figure 7-6). The Hills Point North and Hills Point South bars (NOB 14-5) are located to the north. The Hooper Cove/ Slaughter Creek bar (NOB 15-2) is located to the east, in the Little Choptank River. The Granger/Cators Cove bar (NOB 14-6/15-1) is located at the mouth of Oyster Cove approximately 1000 ft (300 m) southeast of the island. Harvest data for the NOBs in the vicinity of the island are included in the Little Choptank River dockside data. Revenue from the commercial oyster harvest in the Little Choptank River topped one-half million dollars in 1997 through 2000, and it is likely that NOB 14-5, NOB 15-6, and NOB 14-6/15-1 make significant contributions to this industry.

Soft Shell Clams
The soft-shell clam represents a significant fishery in the mesohaline portion of the Chesapeake Bay. James Island is located in the mesohaline portion of the Bay; there is a soft-shell clam fishery in waters west of James Island (Zone 27), which produced 6,907 pounds in 2000 (see Table 6.4 of Appendix E). Soft-shell clams have no reported commercial landings from the Little Choptank River (see Table 6.5 of Appendix E), and therefore are not likely to be a significant fishery in that region. During the Fall 2001 sampling, no soft shell clams were collected at the ten stations, but were collected at two stations (JAM-004 and JAM-010) during the Summer 2002 sampling.

Blue Crabs
The dominant commercial fishery in the Chesapeake Bay is the blue crab industry. James Island is surrounded by shallow water with scattered SAV beds on the eastern shorelines of the three island remnants, a favored summertime blue crab habitat. James Island is located within an area known to support high-densities of male blue crabs in the summertime and is located just north of the high female blue crab summertime range (Funderburk, *et a*l. 1991). However, all shallow areas (areas less than approximately seven ft in depth) within the Bay from the mouth of the Back River in Maryland to the mouth of the Bay in Virginia are included in this range.

The surrounding waters of the island support both hard and soft crabbing industries. In the 2000 season, the Little Choptank River (Zone 53) produced over 400,000 pounds of commercial hard crabs. The zone located northwest of James Island in the mainstem of the Bay (Zone 27) produced over four million pounds of commercial hard crabs in the 2000 season (see Tables 6.4 and 6.5 of Appendix E). Hard crab catches prior to 2000, for 1995 to 1999, produced approximately one million pounds per year. The Chesapeake Bay catches in Zone 27 ranged between approximately 5 and 10 million dollars for the years 1995 through 1999. These statistics indicate the presence of a viable blue crab fishery in the waters surrounding the island. During all site visits to the island, commercial crab pot fields were observed and located at the northern tip of the northern remnant and the southern tip and southwestern portion of the southern remnant.

Finfish

The catch tonnage and revenue for the finfish industry vary widely between 1995 and 2000. Data indicate that striped bass, menhaden, eel, and croaker are the most productive fisheries in the Little Choptank River (Zone 27). Gray sea trout, summer flounder and bluefish also help support commercial fisheries; the spot and channel catfish fisheries appear to be declining in productivity in the Little Choptank. The most significant finfish fisheries in Chesapeake Bay waters west and north of James Island (Zone 53) consist of croaker, menhaden, spot, and striped bass.

The Little Choptank River is reported to be part of the potential distribution range of white perch, which is also fished commercially (Funderburk, *et al.* 1991). Since James Island is located in the mouth of the Little Choptank River it is likely that the island remnants are occasionally within the range of the white perch habitat due to seasonal and yearly variation in habitat characteristics. However, no catch statistics for the white perch industry were available. Due to the shallows, evidence indicates that commercial fishing is limited in the waters

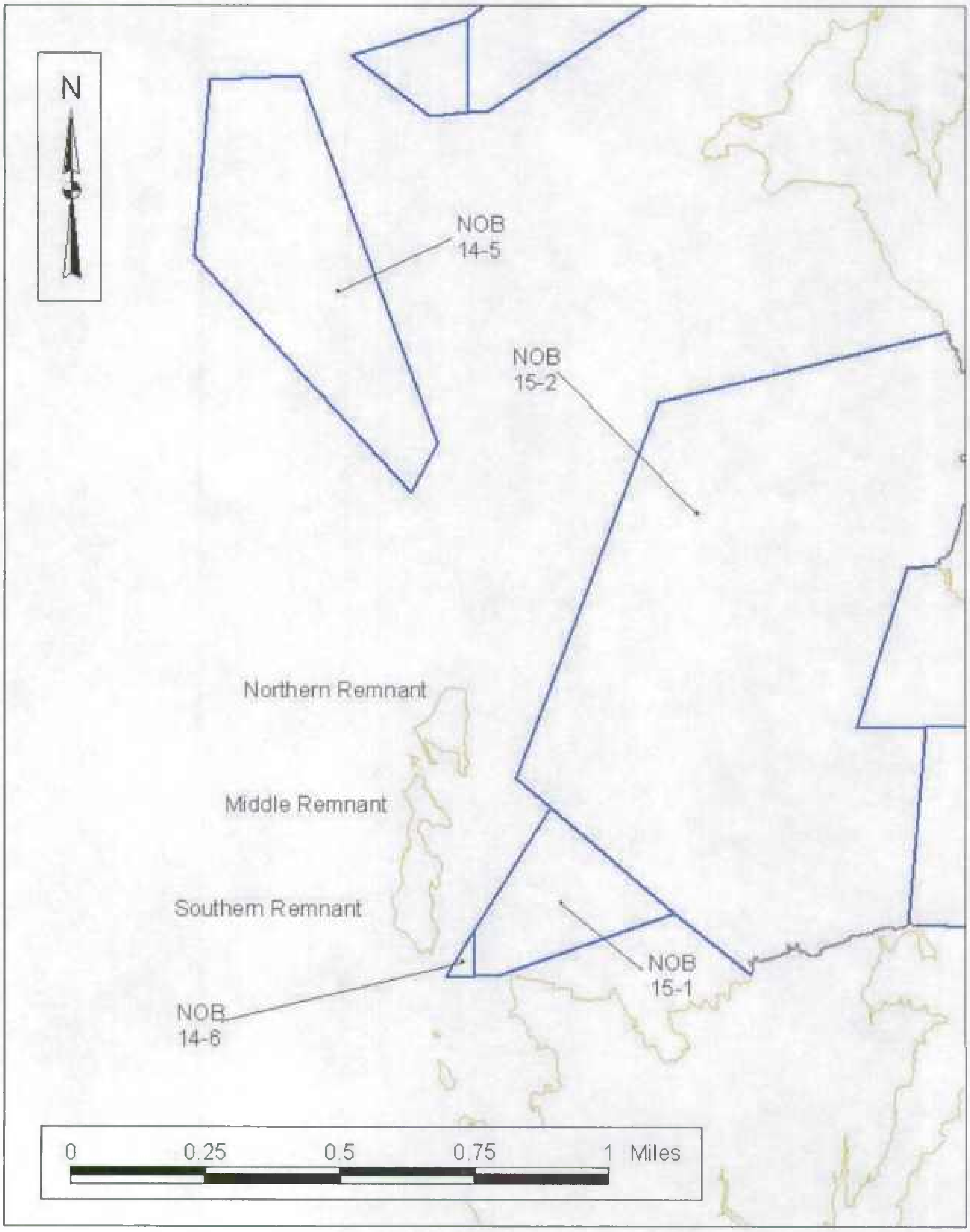

Figure 7-6. Natural Oyster Bars in the Vicinity of James Island

immediately surrounding James Island. No commercial fishing vessels or nets were observed in the proposed concept areas or the surrounding waters during any of the site visits.

7.1.9 Recreational Resources

James Island is privately owned and is not open to the public as a park. The owners and their guests use the island for hunting, fishing, and other recreational purposes. Two duck blinds in good repair were observed on or near James Island during the MES June 2001 site investigation. One duck blind was located on the eastern side of the central remnant and had permit numbers posted on-site. The second duck blind was located in the waters just east of the sandy neck between the northern and central remnant; this blind was not inspected for the presence of permit numbers. Anecdotal evidence tells of further hunting and fishing uses on the island, such as the 1930's release of sika deer on the island (Earnest 2001). Although the island is accessed for hunting and fishing, the shallow waters and snags surrounding it may limit its popularity as a destination for recreational boaters; recreational kayakers may also occasionally use the area. A charter captain also reported that recreational fishing often occurs around James Island. A popular recreational fishing destination is located well offshore to the west, where there is a sharp drop into the deeper waters of the Chesapeake Bay (Young 1999).

7.1.10 Historical Resources

A literature search conducted by MES at the Maryland Historic Trust (MHT) revealed four recorded archeological sites along the eastern shore of the James Island remnants. One archeological site is located either on or submerged adjacent to the neck connecting the northern and middle remnant, a second archeological site is located along the shoreline of what is now the middle remnant, and the remaining two archeological sites are located along the shoreline of the southern remnant. None of the recorded archeological sites appears to be located within the proposed concept areas. The literature review at the MHT revealed no standing structures that have been recorded or nominated as eligible for listing on the National Register of Historic Places (NRHP). No standing structures have been observed during any of the site visits, but ruins of a brick foundation and possible chimney from a home dwelling were observed during the Fall 2001 and Summer 2002 surveys, on the southern remnant.

During the Fall 2001 and Summer 2002 site surveys, the southern remnant showed evidence of the historic use of the island and possible archeological resources. Shards of glass, brick, and pottery were found along the beaches between the northern and southern remnants; these pieces could potentially be archeological artifacts from the households that inhabited the island. The northern and middle remnants showed no evidence of historic or archeological resources. A shell midden is evident along the northeastern shore and pieces of brick and pottery were discovered along the southeastern shore of the southern remnant.

7.1.11 Groundwater

The predominant aquifer systems in Maryland consist of the Chesapeake Group (Eastern Shore only), the Aquia Group (including the Aquia and Piney Point-Nanjemoy subaquifers), the

Severn-Magothy Aquifer, and the Potomac Group (including the Patapsco and Patuxent subaquifers). Confining layers, usually of clay, separate these aquifers.

The Piney Point Aquifer, an Eocene aged sub-aquifer in the Aquia Group, is the primary groundwater source fór the City of Cambridge and southern Dorchester County, including James Island. This is the main source for drinking water for the southern portion of Dorchester County, including James Island. The Piney Point Aquifer occurs at depths between 300 to 400 ft in the vicinity of the island. Due to increased pumping, water levels for this productive aquifer have decreased throughout the entire area since the late 1970's. In areas near the Choptank River and surrounding tidal areas, the water can have high levels of hydrogen sulfides and may require treatment prior to use (Dorchester County Soil Survey).

7.1.12 Aesthetics and Noise

Historic sites listed or considered eligible for listing on the National Register of Historic Places (NRHP) are sometimes protected from aesthetic impacts to their viewsheds. Two historic properties, a farm named Patrick's Discovery (located on the shore of Taylors Island) and Oyster Creek farm (a private residence also located on Taylors Island) may be within the viewshed of the proposed project. Mulberry Grove is a residence and historic farm located on the highest point near the shore of Taylors Island, is due south of James Island, and may have a view of the proposed concept area.

Current noise or sound sources in the area surrounding the island are predominantly the result of natural sources. Additional sound sources, including noise arise from anthropogenic sound sources and can include passing recreational boaters or commercial fishermen and crabbers fishing the shallows. During all site visits, sound sources and noise from the Taylors Island and Hooper Island mainlands were not audible from James Island.

7.1.13 CERCLA Liability

Preliminary evaluations of James Island and the proposed concept areas have indicated that no hazardous, toxic or radioactive substances exist within the project area. A search of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) on-line database (www.us.epa.gov) revealed three hazardous waste sites located in Dorchester County. The closest of the three listed CERCLA sites to the island is located in Cambridge, which is approximately 15 miles northeast. Due to the distance of the three identified sites from the island, it is not likely they have impacted the island or the concept areas; therefore, evidence indicates that no CERCLA liability is associated with the site.

7.1.14 Critical Areas

The Chesapeake Bay Critical Areas Commission regulation designates all lands within 1,000 ft of the mean high tide line or landward edge of adjacent tidal wetlands as a "critical area" (Title 27, Code of Maryland Regulations [COMAR 1992]). The width of the island remnants range from 100 yds to 400 yds in width. By the definition, James Island in its entirety is subject to MCA regulations, due to distance of the island's interior from the shoreline. The proposed concept areas are also considered to be within the state-defined critical areas, since the proposed alignments are located within the tidal waters and tributaries of the Chesapeake Bay. Consultation with Dorchester County would be appropriate if development of the proposed site is undertaken.

7.1.15 Navigation

The proposed project area does not lie within or adjacent to any federal navigation projects or channels. The mainstem Bay channel is located approximately 3 miles west of James Island. The shallow waters around James Island and the potential project site may limit future navigational access to that area, but the shoaling and snags currently impedes navigational access. There is also a small passage that exists between southern James Island and Taylors Island that is used for limited navigation by relatively shallow draft vessels. Use of the site for the placement of dredged materials would support maintenance of regional navigation projects and help prevent further shoaling around the island.

7.2 Potential Environmental Impacts

7.2.1 Potential Impacts to Water and Sediment Quality

Short-term, temporary impacts to water quality and sediment quality would be expected during construction of the proposed alignments. Water quality effects during the placement of dredged material would be minimized through regulatory controls of discharge water quality, similar to the PIERP. Construction impacts would be expected to include turbidity-related impacts and would also be minimized through regulatory controls during construction. As a result, turbidity and pH effects would be monitored and coordinated with the appropriate regulatory agency as effluent from dredged material placement is discharged. Any effects from discharging into background waters are assumed to be localized and likely to consist of heightened suspended solids concentrations, fluctuations in pH, and elevated levels of nutrients. These effects would be short-term and regularly monitored for acceptable levels during all discharge events.

The sediment that would be placed as part of the habitat restoration area would be considered clean. Clean sediments only from the Bay's main stem (east of the North Point-Rock Point line in the Patapsco River) would be included in the project; no Baltimore Harbor sediments (from west of the North Point-Rock Point line) would be deposited into the beneficial use project. Therefore, there would be no negative impacts from contaminated sediments to water quality during discharge. The sediments to be inflowed as part of the habitat restoration area may also be of a different grain size and soil series than the native sediments. However, since the sediments will not be contaminated and the project will result in renewed habitat and protection from erosion for James Island, it is unlikely that different types of clean sediments would adversely affect overall water or sediment quality.

The proposed habitat restoration project should improve overall water quality in the vicinity of the island by protecting the shoreline from further erosion and thereby reducing suspended solids in the water column. Additionally the project would reduce physical energy from the southwest, west, and northwest, which would be anticipated to have ancillary shoreline protection benefits for some areas in Dorchester County.

7.2.2 Potential Impacts to Biological Resources

The habitat restoration construction in the potential concept areas would occur entirely in the water column, located to the west of James Island. The alignments are completely separated from the remnants and are not anticipated to directly affect the vegetation, structure of the shoreline, SAV, or inland marsh habitats. Short-term, temporary impacts from noise and construction activity may cause terrestrial species to avoid the areas closest to the construction, but these effects would diminish after construction is completed.

Currently, there have been no reported catches of the Federally-listed endangered species, the shortnosed sturgeon, within 3.5 miles of James Island. Similarly, there have currently been no reported catches of the species of concern, the Atlantic Sturgeon, within the concept area. However, further consultations with NMFS and USFWS about these species is appropriate for higher level studies. During the Summer 2002 site investigation, bald eagles, a federal and Maryland State-listed threatened species, were observed utilizing the habitat on and around the island. In addition, an active bald eagle nest was observed on the middle remnant containing an immature bird near the fledging stage. Bald eagles also currently nest at Poplar Island. Coordination with resource agencies has allowed the Poplar Island project construction operation to proceed with no impacts to the bald eagles. Similar efforts would be undertaken at James Island if the area is selected for restoration. Formal consultations for all RTE species would be required with NMFS, USFWS, and MDNR when higher level studies occur.

SAV mapping during the Summer 2002 sampling effort shows three distinct SAV beds directly adjacent to the eastern side of the northern, middle, and southern remnants, located outside of the proposed project footprint. Construction of the habitat restoration area on the western side may temporarily increase turbidity during construction of the alignment. Once the proposed alignment is complete, the project will help prevent further erosion, and enhance SAV growing conditions in the surrounding waters by decreasing water velocity and wave impacts and decreasing the current concentrations of suspended solids in local waters due to erosion. Decreasing concentrations of suspended solids would allow increased light penetration and improve overall conditions for SAV.

All benthic investigations of the waters surrounding James Island characterize the B-IBI as low, indicating a stressed community. Only one station in ten total stations sampled during two seasons met the CBR Goal. The benthic community located immediately within the footprint of the concept area, approximately 979 to 2,202 acres, would be lost at the time of construction for creation of the dike alignment. The B-IBI metric calculations of the existing benthic community in the shallows were low, so impacts would not be as great as in a more productive area (Llanso, 2001; Llanso, 2000). Additionally, the rock armor of the dike that would be constructed as part of the proposed project, would provide additional interstitial habitat for the benthic community (similar to what is currently occurring at the PIERP and a benthic community within the created wetlands would also be expected to become established). The waters within the concept area are generally too shallow to be favored for wintering male blue crabs. However, if any blue crabs burrow in the footprints of the proposed alignments sediments during the winter, they would be lost if any construction occurred during this time period.

Essential Fish Habitat
James Island lies within an area that generally provides EFH area for nine species (Section 7.1.3 for a detailed discussion). Consultations with NMFS have indicated that three species, the bluefish, the summer flounder, and red drum would be the species of particular concern at James Island (Nichols 2002). These species support modest commercial fisheries in the Bay and Little Choptank River. Juvenile red drum and summer flounder were collected in beach seine samples during the Summer 2002 aquatic sampling. In addition, common forage species that contribute to the EFH were also collected in abundance near James Island. The eastern side of James Island would be considered HAPC for summer flounder and red drum due to the presence of SAV beds. This area would have minimal impacts from the construction of any proposed alignments. Bluefish are expected to be transient to the area and may be collected in gillnet samples that will be conducted as part of the ongoing studies of the area. An in-depth analysis of EFH relative to James Island is included in Section 6 of Appendix E. Habitat within the proposed concept area does not appear to be unique relative to any of the EFH species of concern. Although evidence suggests that there will be no negative impacts to the identified EFH species, further consultations with NMFS will be required for future studies.

7.2.3 Potential Impacts to Commercial Fisheries

Any commercial harvesting, such as crabbing, that currently takes place within the proposed habitat restoration alignments, ranging from 979 to 2,202 acres, will be displaced by the project construction. No fixed fishing gear was found within the area of the proposed footprint during any of the site visits or sampling seasons. It appears that commercial finfishing would likely be the least affected fishery. Construction of the habitat restoration area is not expected to greatly affect the menhaden fishery as it is distributed throughout the Bay.

Impacts to the soft-shell clam fishery should be minimal, since the current, degraded state of the benthic community most likely limits any commercial clamming within the concept area. Commercial crabbing currently occurs within the five proposed alignments located off the northern and southern ends of the island remnants, and would be displaced following construction. State recognized or historical NOBs are not located within the proposed alignment areas. Alignments 3, 4, and 5 are closest to NOB 14-5; all three dike alignments end approximately 900 ft south of NOB 14-5 (Figure 1-2 for dike alignment locations). Alignment 2 is closest to NOB 15-2; it extends eastward across the northern shallows of James Island, and ends approximately 750 ft away from the NOB. Alignment 1 is the smallest dike configuration and is approximately 3,000 ft away from NOB 14-6/15-1 at its closest point to any NOB. All dike alignments are at least 700 ft from any recorded NOB. Negative impacts to the three NOBs should be minimized or avoided during construction of the dike enclosure. Further consultation with MDNR will be required concerning the proximity of construction to NOBs and the displacement of active crabbing sites. Restrictions on construction activities during specified seasons and times of the year are expected to minimize impacts to the nearby oyster bars and active crabbing sites during alignment construction.

Completed construction of the habitat restoration area should ultimately improve water quality in the general area by reducing erosion and the resulting suspended solids. In the long run, this may help sustain or improve the oyster fisheries in the area and promote a revived clam fishery.

7.2.4 Potential Impacts to Recreational Resources

Recreational fishing and boating that currently occurs within the concept areas would be permanently displaced by the proposed alignments, ranging from 979 to 2,202 acres. However, it is likely that the shallow depths that currently exist prevent use in the nearshore areas by many sailing vessels, so the proposed alignment would primarily affect watercraft such as motorboats. It is expected that fish species would slowly begin to utilize the shoreline structure of the beneficial use project following construction, and that fishing would also resume in the waters around the site, similar to what is currently occurring at Poplar Island. Seasonal, private hunting currently occurs on the island, and some of these activities may be temporarily affected by the island's proximity to the proposed beneficial use area, which may displace waterfowl during construction.

7.2.5 Potential Impacts to Historical Resources

James Island was once utilized for both residential and agricultural use during the 19th and early 20th centuries. During all site visits, glass, brick, and pottery shards were found along the beaches. Additionally, a shell midden and brick ruins from foundations and a possible chimney were observed on the southern remnant. The MHT records show four archeological sites located along the eastern shores of the island, but none of these sites are reported to be within the alignment areas. If there are no known archeological sites within the alignment areas, the proposed project will protect the remnant islands and the existing artifacts and foundations within them from future erosion. Formal consultations with the MHT would be appropriate if feasibility investigations of this site are conducted. Construction of the habitat restoration area would not be significantly visible from these locations due to the distances of the identified historic properties from the island. Further consultation with MHT may be needed on this issue.

7.2.6 Potential Impacts to Other Resources

The potential contamination of groundwater is a concern for projects of this type. The geological characteristics of this area indicate that there is no connection between the project areas and the aquifer. Furthermore, only clean material from east of the North Point-Rock Point line will be used for the project and no contamination is expected.

Homeowners along the northern shore of Taylors Island and recreational boaters may experience some viewshed and sound disturbances during construction. These disturbances should be temporary and minimized by distance. Construction of the habitat restoration area may be visible from three of the four historic properties identified on Taylors Island. Although the proposed project will be over two nautical miles away from the location of the historic properties and consistent with historic viewsheds, further consultation with MHT may be required.

During temporary construction and filling activities, noise disturbances to recreational boaters may occur, but noise disturbances are not expected elsewhere due to the remoteness of fixed receptors, such as homes, to the potential construction areas.

There is no indication of a CERCLA liability connected with the proposed concept area, thus no impacts from CERCLA liability associated with the proposed project are expected to occur.

Negative impacts to navigation are expected to be minimal since local knowledge is required to navigate the shallow waters immediately adjacent to the island. However, the proposed alignments of the restoration project could potentially decrease or divert watercraft passage through this area. The proposed alignments would not block the small passage that exists between southern James Island and Taylors Island. Barge and tug traffic that transport materials to the proposed alignment may interact with commercial and pleasure boats, but only during the construction of placement phases of the project. In the long-term, the project is expected to have positive impacts to regional navigation because it will be supporting Federal Navigation Channel maintenance dredging.

The proposed alignment areas are located in Chesapeake Bay critical areas. The MCA regulations may not result in a significant concern since the activities related to construction of the proposed alignments and placement of fill material will occur only as a temporary disturbance and only during a limited time period. In addition, the James Island habitat restoration product will be consistent with the critical areas conservation intent, and the issue should be mitigated due to the beneficial use component of the project. However, consultations concerning the critical areas would occur if the proposed project moves forward.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

James Island is currently being considered as a habitat restoration site for the beneficial use of dredged material. The non-profit citizen organization, DCRPDC, originally suggested James Island as a beneficial use project for island habitat restoration. In addition to support from DCRPDC, MPA, and MDOT, the landowners of James Island indicated their support of the proposed restoration program as well. After the necessary support for this restoration project, studies were initiated to determine the feasibility of the project. The study elements described in this consolidated report include the findings of the following separate investigations: subsurface geotechnical investigations; coastal engineering investigations; hydrodynamics and sedimentation modeling; dredging and site engineering (including design and cost specifications); and the environmental conditions at James Island. The analysis of the individual studies was conducted at a reconnaissance level and the results should, therefore, be considered preliminary. If this site is considered for further evaluation, feasibility level studies would be conducted prior to implementing the proposed project. General and specific conclusions are detailed below.

General Conclusions

- Historic and current mapping of the island have indicated that James Island was originally estimated at 976 acres in 1847. Recent estimates from 1994 measure the island at only 92 acres, which denotes a loss of approximately 800 acres since 1847.
- An analysis of the bathymetry shows that water depths within the proposed project area vary between –2 and –12 ft MLLW, while water depths are approximately –1 to –4 ft MLLW in the area adjacent to the island remnants.
- The James Island habitat restoration project is anticipated to produce positive, long-term environmental effects to the James Island remnants and the surrounding area. The project is expected to have an overall positive effect on aquatic resources in the area by stabilizing the eroding banks of James Island and restoring the eroding wetland and forested habitats. The project is also expected to protect other nearby shorelines of Dorchester County, and improve the overall water quality in the area. Furthermore, additional wetland and upland habitats will be created as part of the proposed alignments.
- This habitat restoration project will also have positive impacts on regional navigation by providing needed dredged material placement capacity for channel maintenance materials.

Geotechnical Conclusions

- The foundation soils in most areas consisted of silty sand, suitable for supporting a dike. Some soils were soft, silty clays at the mud line that will require undercutting and backfilling with sand. In addition, the site contained a sufficient quantity of suitable borrow for constructing the perimeter dike to an elevation of 20+ ft.

- The site was found to contain a sufficient quantity of suitable borrow for constructing the perimeter dike to an elevation of 20+ ft. It is estimated that the total borrow sand available is about 15 mcy. The net quantity of sand available (assuming a 15% loss of fines during construction) will be about 12+ mcy.

Coastal Engineering Conclusions

- The highest waves for the site approach from both the north and south. From these wave forecasts, seven preliminary cross-sections were developed for the containment dikes. The dike designs are based upon a 35-year return period.

- Dike heights are based on allowable overtopping for an unarmored crest and an allowance for settlement. The dike design incorporates a 3:1 side slope, above grade toe protection, a core constructed of sand, and a crushed stone roadway on the structure crest.

- Overall, seven dike cross-sections were designed for the five proposed alignments. Each of the five alignments would require four to five different dike cross-sections for construction with the necessary minimal heights.

Hydrodynamic and Sedimentation Modeling Conclusions

- Hydrodynamic and sedimentation modeling for the James Island restoration project show minimal impacts on local tidal elevations, which remain essentially unchanged. Current velocities are impacted following island construction, with maximum increase or decrease in current velocity of about 0.5 ft/sec.

- The project construction at James Island would have beneficial effects on sedimentation rates and patterns, with less erosion of the James Island shoreline and the shallow areas surrounding the remnant James Islands. Some protection would also be afforded to the shoreline of Taylors Island from wind and waves coming from the N, NNW, and NW directions. This reduction in erosion would likely reduce suspended sediment and improved water quality.

Dredging and Engineering Conclusions

- There are currently five alignments each with upland dike height scenarios of +10 ft and +20 ft MLLW elevation, and two borrow source options for each alignment, totaling 20 combinations for the James Island habitat restoration project. In addition, each alignment consists of a 50 to 50 wetland-to-upland ratio habitat area, with wetland cells to +8 ft MLLW.

- The design acreages of the alignments range from 979 acres to 2,202 acres. Alignment 1 is the smallest layout and would have a design acreage of 979 acres while Alignment 4 is the largest of the five site designs and would have a design acreage of 2,202 acres.

- For the 10-ft upland dike elevation alternative, the site capacity for the five alignments ranges between 23 and 52 mcy and the overall cost of construction ranges from $406 to $759 million. For the 20-ft upland dike elevation alternative, the site capacity for the five alignments ranges between 35 and 79 mcy and the overall cost of construction of this project ranges from $591 million to $1.106 billion.

- The schedule for construction of the 10-ft dike elevation is 2 to 3.5 years and the total costs per cubic yard of site capacity range from $14/cy to $18/cy. The schedule for construction of the 20-ft dike elevation is 3-4 years and the total costs per cubic yard of site capacity range from $14/cy to $17/cy.

Environmental Conditions and Potential Affects

- *In situ* water quality results for salinity, pH, and temperature were typical of the salinity regime for this reach of the Bay and within the range expected for the Fall 2001 and Summer 2002 surveys. DO readings were atypical of shallow, well-mixed waters of the Bay and reflect a membrane tear over the DO probe. Although the *in situ* water quality was typical for the region, lower than normal precipitation could have affected benthic distributions in the area in Summer 2002.

- Water depths at the site are relatively shallow and hypoxia and/or anoxia are not expected. Aerial photographs show that localized turbidity plumes currently extend outward from James Island, possibly affecting benthic habitat. Turbidity was low at all locations but somewhat elevated along the shoreline, which is expected.

- Chemical analyses of sediments from around the island remnants indicated that, of the 155 chemical constituents tested in the sediment, 57 were detected in James Island sediments. The majority of these detected constituents were found in low concentrations, and were representative of background concentrations. SVOCs, VOCs, and organophosphorus pesticides were not detected in any of the sediment samples. One PAH, acenaphthylene, exceeded the TEL value at sampling location JAM-002 by a factor of approximately 2.6 but did not exceed PEL values. None of the other detected chemical constituents exceeded TEL values.

- Fisheries investigations of the shorelines indicated that the aquatic areas around James Island support a fairly diverse fish community, including young of commercially important species. All species were typical of the region. Mobile, aquatic species will be displaced within the concept area (979-2,202 acres). James Island lies within an area that generally provides EFH for nine fish species. Two EFH species, juvenile red drum and summer flounder, were collected during aquatic sampling. However, habitat within the proposed concept area does not appear to be unique relative to any of the EFH species of concern. Although evidence suggests that there will be no negative impacts to the identified EFH species, further consultations with NMFS would continue for future studies.

- Ichthyoplantkton densities were relatively high and were dominated by the bay anchovy. Zooplankton were typical of the region. In general, the benthic community was typical of this area of the Bay but was dominated by a single species at most stations. The majority of the species found were stress-tolerant, resulting in low B-IBI scores at most locations in both seasons of sampling. These B-IBI scores indicate that the benthic community surrounding James Island is currently degraded in surrounding waters. Benthic organisms residing within the footprint of the concept area would be buried during construction as the open water habitat is converted to wetland and upland habitats. However, by protecting James Island from further erosion, the restoration project may improve conditions conducive to a healthy benthic community.

- The James Island remnants currently support SAV growth along their eastern shorelines consisting of SAV beds dominated by widgeon grass, located in areas outside of the proposed project design. In addition, small pockets of sea lettuce, which is considered a macroalgae and not a true SAV, were located in one of the beds of widgeon grass. No SAV beds have been reported within the concept area, located on the western side of James Island. Construction of the habitat restoration area on the western side of the island may increase turbidity during construction; but once construction is complete the restoration project should improve overall water quality by decreasing turbidity and promoting conditions for SAV growth in the area.

- James Island currently consists of three eroding island remnants. The remnants are primarily forested and the shorelines consist of fringe marshes and eroding wooded banks lined with submerged snags. The shoreline elevations range from 5 to 10 ft on the northwestern shores and gradually decrease in elevation to the south. The proposed restoration area alignments are not attached to the existing remnants and therefore are not expected to adversely impact terrestrial vegetation, including wetlands, on the island. Construction of the habitat restoration area on the western side of James Island should protect terrestrial and wetland vegetation from continued loss due to erosion.

- Avian utilization of the island was typical for this area of the Bay. No large bird colonies (e.g. gulls, egrets, pelican, etc.) were found on the island. The island does provide nesting habitat for a variety of song birds and raptors. There was also evidence that several other terrestrial species utilized the island. The habitat restoration area is expected to provide additional nesting habitat for birds and wildlife habitat. Noise and activity from the construction may cause terrestrial species to avoid the areas of James Island closest to the construction, but these effects would be short-term.

- The Federal and Maryland state-listed threatened bald eagle utilizes the area in and around James Island. An active bald eagle nest with a fledging was observed on the middle remnant. Several other avian species identified at James Island during the Fall 2001 and Summer 2002 surveys have conservation status determinations associated with their breeding status. Time of year restrictions during construction would be expected to minimize impacts to conservation species. Currently, there have been no reported catches of the Federally-listed endangered shortnose sturgeon, or the species of concern, the Atlantic sturgeon, in the vicinity of the concept area. Future consultation concerning RTE species will occur if feasibility investigations of this site are conducted.

- Any commercial harvesting, such as crabbing, that currently takes place within the proposed habitat restoration area footprint will be displaced by construction. Three NOBs are located in the vicinity of James Island but are not located within the concept area. Completed construction of the habitat restoration area is expected to improve water quality in the area by reducing erosion and the resulting suspended solids, which may help sustain or improve the shellfish resources in the area. Time of year restrictions on construction activities would be expected to minimize impacts to the nearby oyster bars during construction.

- Recreational boaters and residences on the northern shore of Taylors Island and eastern shore nearest James Island may experience some minimal, temporary viewshed disturbance during construction of the project. Noise disturbances to boaters during construction and filling activities is possible, but shoreline residents should not be affected, due to distance. Impacts to navigation are expected to be minimal because few boats can currently utilize the shallow waters immediately adjacent to the island.

- The Maryland Historic Trust records show four archeological sites located along the eastern shores of James Island. During site visits, a shell midden and brick ruins from foundations and a possible chimney were observed on the southern remnant as possible archeological or historical artifacts. No archeological sites are reported to be within the concept areas. Construction of the habitat restoration area may be visible at a distance from two of the four historic properties identified on Taylors Island. Formal consultations with the MHT would be appropriate if feasibility investigations of this site are conducted.

- Use of the site for the placement of dredged materials would support maintenance of regional navigation projects and help prevent further shoaling around the island.

8.2 Recommendations

Based upon the current studies and consultations with the Baltimore District USACE, MES, and NMFS, recommendations for future studies are included below.

- *In situ* sediment quality results and analyses indicate that there is very low possibility for potential effects to biota and therefore, no further sediment quality investigations are suggested for the feasibility-level of this study.

- Fisheries studies would benefit from addition of gillnet collections to capture the transient species in the areas outside of the shore-zone. Therefore, it is recommended that fisheries studies be conducted during four seasons. All other fisheries and plankton sampling should be conducted as a quarterly collection effort since these resources change significantly with season. In addition, coordinate with NMFS concerning EFH.

- Nutrient sampling and analyses are recommended to be conducted at all benthic locations.

- Benthic sampling is not required for Fall 2003 since data previously exists from a fall period. At a minimum, benthic sampling is recommended to be conducted again during the spring. Winter sampling would probably not yield results that differ significantly from fall sampling, so winter sampling is not recommended.

- Bird observations are recommended during all seasons because avian utilization of various habitats can change dramatically with season.

- Terrestrial and vegetation resources are recommended to be monitored for changes but additional in-depth studies are not necessary at the feasibility-level of study because the proposed project will not directly impact these resources.

- Quantitative SAV surveys are recommended to be conducted during the spring and summer.

- Continued coordination concerning the SNS and other RTE species such as the bald eagle are recommended as on-going coordination efforts as well as obtaining a biological opinion for the site.

- Evaluating the commercial harvesting and an assessment of the recreational boating and fishing activity in the vicinity of the proposed project is recommended.

- Confirming the locations and depths of wells and performing a more in-depth analysis of groundwater in the area is recommended.

- Coordination with the MHT regarding archaeological resources in and within the vicinity of the concept area is recommended. Also, discussing the viewshed impacts on the historical properties identified on Taylors Island with the MHT is recommended.

- Coordination with Dorchester County regarding Critical Areas issues is recommended.

- Conducting in-depth geological field investigations to identify potential and size of sand borrow available at the site and conduct geotechnical field studies is recommended.

- Conducting in-depth and reconnaissance-level coastal engineering investigations and dredging site engineering studies are recommended along with performing hydrodynamic investigations.

- A feasibility study for engineering designs would be necessary to implement the proposed project.

- Studying the potential for connecting the proposed habitat restoration project to Taylors Island should also be considered.

- Finally, an in-depth examination of sub-bottom acoustic data and side scan sonar data collected in 2000 (to identify potential submarine archeological or buried shell resources) is recommended.

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APPENDIX A

Appendix A:

Subsurface Geotechnical Reconnaissance Study

(Engineering, Construction, Consulting, and Remediation)

E2CR inc.

ENGINEERING · CONSTRUCTION · CONSULTING · REMEDIATION

GEOTECHNICAL RECONNAISSANCE STUDY

FOR:

JAMES ISLAND

CHESAPEAKE BAY, MARYLAND

MPA Contract No. 500912
MPA Pin No. 600105-P
MES Contract No. 01-07-13
E2CR Project No. 01572-04

PREPARED FOR:

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AUGUST 30, 2002

ENGINEERING • CONSULTATION •
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CONSTRUCTION • REMEDIATION •

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August 30, 2002

Mr. Dennis Urso, P.E.
Gahagan & Bryant Associates, Inc.
9004 Yellow Brick Road, Suite O
Baltimore, MD 21237

Re: Geotechnical Reconnaissance Study
James Island – Chesapeake Bay, Maryland
MPA Contract No. 500912
MPA Pin No. 600105-P
MES Contract No. 01-07-13
E2CR Project No.: 01572-04

Dear Mr. Urso:

In accordance with our revised proposal dated October 31, 2001, and your verbal authorization, we have completed the preliminary feasibility study. Transmitted herewith are 13 bound copies and one unbound copy of our revised Geotechnical Reconnaissance Report. Also enclosed is an electronic copy of this report in PDF format.

Should you have any questions, or need any additional information, please give us a call.

Very Truly Yours,
E2CR, INC.

G.V. Kumar, Ph.D.
Project Engineer

Siva Balu, P.E
Chief Executive Officer

Word/2001 Reports/James Island CL

ENGINEERING • CONSULTATION •

E/2 C/R inc.

CONSTRUCTION • REMEDIATION •

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JAMES ISLAND
GEOTECHNICAL RECONNAISSANCE STUDY

EXECUTIVE SUMMARY

This report presents the results of the preliminary geotechnical reconnaissance study conducted for the proposed beneficial use of dredged material project along the western shoreline of James Island in Dorchester County, Maryland. Five dike alignments were evaluated in this study. These five dike alignments enclose an areas ranging between 978 acres to 2200 acres.

The study focused on the subsurface conditions along the proposed alignments, the suitability of the foundation soils for supporting the dike, the availability of suitable borrow to construct the dike, and developing a preliminary dike section. A total of 22 soil borings were drilled to depths of 27.5 feet to 70 feet below the water level and laboratory testing was performed to evaluate the classification, shear strength, and compressibility of selected soil samples. Field investigation was also supported by conducting Electric Cone Penetrometer tests at 4 locations and in-situ vane shear strength tests at 8 locations.

The borings drilled along the proposed dike alignments indicate that the foundation soils in most areas consist of silty sand which will be suitable for supporting the dike. Some of the borings, however, encountered soft silty clays at the mud line that will need to be undercut and backfilled with sand. For these areas, the depth of required undercut is anticipated to range from 5+ feet to 15+ feet with an average of about 10 feet.

The site was found to contain a sufficient quantity of suitable borrow for constructing the perimeter dike to Elevation +20 feet. Suitable borrow was defined as sand with less than 30% fines. It is estimated that the total borrow sand available is about 15 million cubic yards. The net quantity of sand available (assuming a 15% loss of fines during construction) will be about 12+ million cubic yards.

A slope stability analysis was performed to develop a preliminary design section for the perimeter dike. For a dike constructed to Elevation +20 feet, it was determined that the side slopes should have an inclination of 3H: 1V or flatter and that sand borrow containing less than about 30% non-plastic fines should be used.

I INTRODUCTION

This report presents the results of the geotechnical reconnaissance study conducted in association with the conceptual development of a proposed beneficial use of dredged material project at James Island, in Dorchester County, Maryland. The overall study is being performed by the Maryland Environmental Service (MES) and is sponsored by the Maryland Port Administration through MES. This investigation was conducted for Gahagan & Bryant Associates, Inc., in general accordance with E2CR's proposal dated October 31, 2001, and was verbally authorized by Gahagan & Bryant Associates, Inc.

II SITE LOCATION / DESCRIPTION

James Island is located on the east side of the Chesapeake Bay, in Dorchester County, Maryland as shown on Figure 1 in Appendix A. It is located about 15 nautical miles south of Poplar Island as shown on Figure 2 in Appendix A. The depth of water in the alignment areas varies from about 5 feet (ft.) to 14 ft. The predominantly north to south littoral drift has caused severe erosion with the shoreline subject to high wave energies from the Chesapeake Bay. Since 1847, an estimated 78% of James Island has been lost to erosion with most of the erosion occurring on the western side of the island, as shown on Figure 3 in Appendix A (Maryland Geological Survey, 1997).

III PROJECT DESCRIPTION

It is proposed to construct a beneficial use of dredged material project to restore and create island habitat. The project would be protected by a dike system along the western shoreline of James Island. Five dike alignments are being evaluated as shown on Figure 4 in Appendix A. The layouts of five dike alignments enclose an alignment area between 978 acres to 2200 acres as shown on Table 1 in Appendix B. The dike system will be separated from the existing island by about 500 ft. of water.

The dike will be constructed by hydraulically or mechanically dredging the sand from the borrow area, stockpiling the sand if necessary, and then hydraulically or mechanically depositing the sand along the dike alignment. Hydraulic placement offers certain construction advantages and was used for analytical purposes in this report. It should be noted that if the dike is constructed using only mechanical dredging, the properties of the sand in the dike would change. This could affect the stability of the dike, specially shallow failures. The outside face of the dike will be protected from wave action by armor stone.

The wetlands and uplands within the diked area will be created from sediments dredged from approach channels to Baltimore Harbor. The wetland and upland area will be split 50/50. The top of the exterior dike enclosure, where needed, is expected to vary from Elevation (El.) 5 ft. to El. 20 ft. For design purposes, the most severe case was assumed. Hence, the top of the dike was assumed to be at El. +20 ft. for this reconnaissance study.

IV PURPOSE AND SCOPE

The purpose of this reconnaissance geotechnical investigation was to:

i) Evaluate the geotechnical conditions at the site, especially along the proposed alignments;

ii) Design a stable dike section at the site in order to establish a preliminary cost estimate for developing the site;

iii) Evaluate the availability of borrow material (sand) at the site, for the construction of the dike.

It should be understood that this investigation was preliminary and not a design investigation. The design phases should be conducted at a later date.

The scope of this study included the following:

- Review the available data such as Maryland Geological Survey (MGS) and Soil Conservation Service (SCS) data.
- Field investigation: drilling 22 boring and obtaining Shelby tube samples; conducting Electric Cone Penetrometer Tests (CPT) at 4 locations; and conducting in-situ vane shear strength tests at 8 locations.
- Laboratory Testing: conducting laboratory tests to determine the stress history, strength characteristics, index properties of various strata; and suitability of borrow area soils.
- Evaluation: Geotechnical data evaluation, conducting slope stability analysis for the proposed dike system; evaluating the soils at the site for possible use for constructing the dike.
- Preliminary design and report: Preparation of a geotechnical report, including developing a dike section for use in preparing a cost estimate. The evaluating of off site borrow areas was outside the scope of this study.

V FIELD INVESTIGATION

The field investigation was conducted in November and December 2001. A total of 22 borings (JB-1 through JB-22) were drilled at the approximate locations shown on Figure 5: Test Boring Location Plan in Appendix A. All borings were drilled using a trailer mounted drill rig placed on a barge. Standard penetration tests were conducted and split spoon samples were obtained in every boring at depth intervals of 2.5 ft. to 5 ft. A representative portion of each sample was placed in a glass jar and was appropriately marked. Three inch Shelby tube samples were obtained in borings JB-5 to JB-7, JB-9, JB-11 to JB-15, JB-19 to JB-21 in the cohesive soils. All samples were sent to the laboratory for further testing. The depth of the borings varied from about 27.5 ft. to 70 ft. below the water level as shown in Table 2 in Appendix B.

All borings were inspected and the samples were logged and classified by a geologist. The edited logs of the borings are included in Appendix C.

CPT tests were conducted at four locations, designated as CP-1 through CP-4 (see Figure 5 in Appendix A). The tests were conducted in general accordance with American Society for Testing Materials (ASTM) D-3441, using the back of the drill rig to push the rods. Tip resistance, local friction and pore pressures were measured and recorded on an on-board computer. At each location, the rods bent significantly either due to the instability of the barge or other reasons. When this occurred, the CPT was stopped and the hole was advanced using the hollow stem augers and the drill rig, and the CPT was resumed after the hole had been advanced with the hollow stem auger for some depth. This is reflected in the CPT log and in the log for CP-1 through CP-4. The CPT data was sent to the office for interpretation and analysis. The field CPT data and its interpretations are included in Appendix D.

In-situ vane shear tests were conducted at 8 locations in borings JB-13, JB-14, JB-15, JB-20, and JB-21. The vane shear tests were conducted in accordance with ASTM D-2573. The vane shear test basically consists of placing a four-bladed vane in the undisturbed soil and rotating it from the surface to determine the torque required to cause a cylindrical surface to be sheared by the vane. The unit shearing resistance is calculated from the torque force. After establishing the undisturbed shear strength, the sensitivity of the soil was determined by reperforming the vane test on the remoulded soil. The interpreted in-situ vane shear data is presented in Table 3 in Appendix B.

VI LABORATORY TESTING

All samples were visually classified in the laboratory by a geotechnical engineer to corroborate and/or modify the field classifications. Selected samples were tested for their natural water content, Atterberg limits, sieve analysis, percent fines, shear strength (unconfined compression tests, torvane and pocket penetrometer tests) and consolidation characteristics. A total of 151 water contents, 11 Atterberg limits, 12 sieve analysis, 41 percent fines, 4 consolidation tests and 9 unconfined compression tests were conducted. All tests were conducted in accordance with

ASTM procedures. The results of the laboratory tests are included in Appendix E. Summary of laboratory test results are presented in Table 3 in Appendix B.

VII PUBLISHED DATA

The available data that was reviewed included:

- Maryland Geologic Survey (MGS) Reports and Maps (Figure 6 in Appendix A)
- Soil Conservation Service Publications for Dorchester County
- MGS's side scan sonar profiles (Figure 7 in Appendix A). The survey was conducted by MGS on August 7, 2001 and the sonar profiles were used to locate some borings.

A. Area Geology

The site lies in the Coastal Plain Physiographic Province. According to the MGS, the surface soils of James Island consists of Tidal Marsh Deposits (Qtm) and soils of the Kent Island Formation (Qk), see Figure 6 in Appendix A. The Tidal Marsh Deposits consists of soft silt and clay sediments containing thin beds of sand. The stratum is relatively thin (typically less than 10 ft.) and is underlain by the Kent Island Formation. This formation consists of interbedded layers of sand, silt and clay and ranges from approximately 10 ft. to 25 ft. in thickness. The soils underlying the Kent Island Formation are known as the Chesapeake Group, which consists of loose micaceous sand interbedded with dark silt and clay. A geologic cross section near James Island is shown in Figure 8 in Appendix A.

VIII SUBSURFACE CONDITIONS

The subsurface conditions along the perimeter of the dike and in the potential borrow area (within the diked area) are significantly different and are therefore, discussed separately.

A. Foundations

From a geotechnical consideration, only dike alignment numbers 1 and 4 are distinctive are therefore considered herein. All other alignments are overlapping or slightly extending from each other. The subsurface conditions with reference to foundation bearing and slope analysis, does not significantly change between the alignments, based on widely spaced preliminary borings. Therefore, only dike alignments numbers 1 and 4 are discussed in detail.

The borings indicate that the subsurface stratigraphy along the perimeter dike numbers 1 and 4 generally consist of three major strata, as shown on Figures 9 and 10 – Generalized Subsurface Profile in Appendix A.

Stratum I: This consists of very soft, dark gray, silty clay. The standard penetration resistance (N value) is generally WOR (weight of rods) to WOH (weight of hammer). Laboratory tests indicate that the natural water content is generally between 40% to 60% and the shear strength is less than 200 psf. The stratum is highly discontinuous and is believed to be the redeposited soil in the erosion channels of Stratum II. It is up to 15 ft. thick (in CP-2). It was encountered in borings JB-9, JB-21 and CP-2.

Stratum II: This consists of loose to dense gray, brown slightly silty to silty sand with pockets of silty clay. The standard penetration resistance varies from WOH to 40 blows/foot, but is generally less than 15 blows/foot. Its thickness varies considerably from zero (in boring JB-21) to 40 ft. in boring JB-4. The fines content (i.e. percent passing U.S. standard sieve No. 200) varies from 5% and 30% in the sand. The sand is semi-angular to angular, and is generally medium to fine. This stratum is believed to be the Kent Island Formation. Based on correlations with N values, the angle of internal friction (ϕ) is estimated to be in excess of 28°.

Stratum III: This stratum consists of greenish gray silty clay with pockets/layers of green gray, light gray silty sand. It underlies Stratum II under the entire site. The N values varies considerably from 2 blows/foot to 50 blows/2inch, but is generally less than 10 blows /foot in the clay portion and more than 30 blows/foot in the sand portion. The stratum is pre consolidated. Limited laboratory tests indicate that the maximum preconsolidation pressure (P_c) is about 2 ksf. This is interpreted to mean that the island, along the proposed alignments (1 to 5), extended up to about El. +8 ft. The geotechnical properties of the clay portion are as follows.

Liquid limit (LL)	21% to 42%
Plasticity Index (PI)	11% to 28%
Water Content	27% to 40%
Sensitivity	2 to 6

In JB-16, the liquid limit is 84% and plasticity index is 31%. Generally, the water content is close to or even greater than the liquid limit.

The shear strength of the stratum was evaluated based on the empirical correlation between N and C; vane shear, unconfined compressive strength, CPT, and stress history. The shear strength data was found to vary considerably. For preliminary design, the cohesion has been assumed to be 800 psf (to about El. –40 ft.), based primarily on the vane shear, S_u/P_c relationship and unconfined compression tests.

Below El. –40 ft., Stratum III generally indicates N values in excess of 25 blows/foot. Therefore, the cohesion of this stratum below El. –40 ft. is estimated to be in excess of 1800 psf.

It should be noted that Stratum III does contain some significant pockets of silty sand, especially in boring JB-4.

This stratum is believed to be part of the Chesapeake group formation.

B. Borrow Areas

The subsurface conditions in the borrow area are highly variable. The subsurface condition generally consists of sand at the surface except in some locations where the sand is overlain by dark gray silty clay of Stratum I (see Figures 9 and 10 in Appendix A).

The thicknesses of the clay cover and sand layers at each of the borings locations are presented in Table 4 in Appendix B. The thickness of silty sand varies from about 5 ft. to 40+ ft., but generally ranges from 5 ft. to 15 ft.

Laboratory tests indicate that the percent fines content in the silty sands (of Stratum II and III) vary from 5% to 40%, but is generally less than 30%, as shown in Table 3 in Appendix B.

IX EVALUATION AND ANALYSIS

A. General

The two major issues concerning the geotechnical evaluation of a dredged material placement site are:

- Borrow: Availability of suitable borrow material within the enclosed area:

The borrow should ideally be a sand, with as little fines (i.e. percent passing U.S. Standard sieve No. 200) as possible. If sand is not available locally, it will either have to be imported (which increases the cost significantly), or the dike would have to be constructed from on-site clay (usually not practical due to the low strength of the clay placed in the dike), or another type of enclosed structure would need to be used.

- Foundation: Foundation conditions under the enclosed (perimeter) dike:

Soft clays in the foundation soils would require flatter slopes for the dike, or steeper slopes and stabilizing berms. Stiff clays and sands are the preferred conditions. Flatter slopes or berms would increase the cost. Additionally, areas that have very soft clays may require the total or partial removal (either by displacement or by undercutting) of the very soft clay. The undercut soil has to be disposed of, either on-site or off-site, and the undercut area has to be backfilled with sand.

In evaluating the stability of a slope, four variables have to be considered:

i) The analytical method used.
ii) Shear strength of the foundation soil and the embankment soil.
iii) The slope of the dike.
iv) Factor of safety : acceptable and computed.

B. Borrow: Quality and Quantity of Sand

In evaluating the borrow area, two variable have to be evaluated: i) quality of sand and ii) quantity (volume) of sand.

i) Quality of Sand

The borings indicate that the sand, in general, is semi angular to angular. The fines content varies from about 5% to 40%, and is generally less than 30% (see Table 3 in Appendix B). The sand is clayey in some areas, and also contains pockets/layers of clay. The sand is considered to be suitable for building the dike. The suitable sand is available in Stratum II and in Stratum III. It should be noted that in some areas, such as borings JB-10, JB-15 and JB-16, the sands are very dense, i.e. in excess of 50 blows/foot. Dredging these very dense sands could be somewhat difficult.

ii) Quantity of Sand

The locations of the potential borrow areas are shown on Figure 11 in Appendix A.

The quantity of sand available in all stratums was estimated based on the limited available data. It was assumed that no dredging will be done within 300 ft. of the toe of the dike. The thickness of clay that will need to be stripped and the thickness of sand available at each boring are shown in Table 4 in Appendix B and are also presented on Figure 12 in Appendix A.

The volume of total sand available is estimated to be about 15 million cubic yards as shown in Table 5 in Appendix B. During construction, the bulking will be minimal, since the sand is loose. In addition, about 15% of the fines will be lost. Therefore, the net quantity of sand available for dike construction is estimated to be about 12+ million cubic yards (see Table 5 in Appendix B).

It appears that adequate sand is available to build the dike to El. 20 ft.

C. Foundation / Slope Stability

i) Analytical Method

Slope stability analyses were conducted using one typical case for the subsurface profile. Purdue University PC STABL-6H program was used to analyze the stability of the slopes. This program incorporates many different analytical methods, such as circular failure and wedge failure. Also, the failures can be analyzed using different approaches, such as the Modified Bishop Method, the Modified Janbu Method and the Spencer Method. The Janbu Method results in Factor of Safety, which is generally considered to be too conservative, and is about 15% less than the Bishop's Method. For this study the Modified Bishop method, which is accepted by the US Army Corps of Engineers (USACE), was used.

ii) Design Parameters (Shear strength of foundation and embankment)

Along the dike alignments, different foundation conditions were encountered. Three general conditions were analyzed as shown below. Based on in-situ and laboratory tests the following design parameters were used for the foundation soils:

a) **Case 1A:**

Elevation (ft.)	Stratum	Type of soil	γ (pcf)	C (psf)	ϕ (Degree)
El. –10 to El. –15	II	Silty sand	120	0	28
El. –15 to El. –55	III	Silty clay	110	800	0

b) Case 1B:

Elevation (ft.)	Stratum	Type of soil	γ (pcf)	C (psf)	ϕ (Degree)
El. –10 to El. –20	II	Silty sand	120	0	28
El. –20 to El. –55	III	Silty clay	110	800	0

c) Case 2:

Elevation (ft.)	Stratum	Type of soil	γ (pcf)	C (psf)	ϕ (Degree)
El. –10 to El. –40	III	Silty clay	110	800	0

d) Case 3:

Elevation (ft.)	Stratum	Type of soil	γ (pcf)	C (psf)	ϕ (Degree)
El. –10 to El. –50	II	Silty sand	120	0	28

γ = Density of soil in pcf

C = Cohesion in psf

ϕ = Angle of internal friction in degree

The dike will be constructed from the on-site sands. In past projects, the ϕ in the dike has been assumed to be 30° above the water and 28° below the water for hydraulically dredged non-plastic silty sands.

All dike sections were analyzed for circular failures (Case 1 to 3). Case 1 was also analyzed for wedge failures through thin sand stratum. It should be noted that if mechanical dredging is used, the ϕ values used in the above analysis would decrease, thereby reducing the factor of safety especially for shallow failures.

iii) Slope of Dike

During construction, the slope of the dike can vary considerably, depending upon the type of soil, placement methodology, and whether the soil is placed above or below the water. Past experience has indicated that dikes constructed from Silty Sands (non-plastic) can achieve slopes as steep as 2H:1V below the water. However, 3H:1V is a more realistically obtainable slope. Also, during dredging, pumping and placement, about 15% of the fines can wash out for hydraulically dredged and placed sand. Thus, if a borrow area has 30% non-plastic fines, the dike will tend to have about 10% to 15% fines. For mechanically dredged and placed sands, the loss of fines would be much smaller. For this reconnaissance phase, it was assumed that the dike would be constructed by hydraulic dredging, and the slopes achievable would be 3H:1V above and below the water table.

iv) Factor of Safety (FS)

a) Acceptable FS:

The acceptable factor of safety, was assumed to be 1.3, at the end of the dike construction phase. This was also based on the experience at the Hart-Miller Island Dredged Material Containment Facility and the Poplar Island Environmental Restoration Project, and was considered to be acceptable to the USACE. The USACE will be involved in the permit process, and will review and approve the final design for this project, if this project is implemented.

b) Computed FS:

The exterior dike design sections for slope stability analysis are shown on Figures 13a, b and c (for exterior dike to El. +20 ft.) and 14a, b and c (for exterior dike El. +10 ft.)

in Appendix A. It should be noted that a 12 ft. wide bench at El. +10 ft. was included in analyzing the stability of the dike at El. +20 ft. The results of the analyses are presented in Appendix F. The summary of the analyses are shown on Table 6 (for exterior dike 20 ft.) and Table 7 (for exterior dike 10 ft.) in Appendix B.

The analysis indicates that the Factor of Safety for the assumed design section is in excess of 1.3 for deep seated and for shallow failures. It is recommended that the exterior slopes (i.e. 3H:1V) of the dike should not be steeper than the design sections shown on Figures 13 and 14 in Appendix A.

D. <u>Undercutting</u>

The borings indicate that soft soils should be anticipated at the surface (mud line) near borings JB-9, JB-21 and CP-2. These soft soils (Stratum I) will need to be undercut. As a preliminary estimate, the depth of undercut will vary from about 5+ ft. to 15+ ft. with an average of about 10 ft. Other areas of soft soils that will need to be undercut should also be anticipated.

X CONCLUSIONS

Based on the limited boring data, the following is concluded:

i) The foundation soils for near dike alignments are anticipated to be mostly loose silty sands, except near JB-9, JB-21 and CP-2, where the soils are silty clay.

ii) The silty sands of Stratum II and the silty clay of Stratum III are considered to be suitable for supporting the proposed dikes with exterior slope of 3H : 1V and the top of dike at El. +20 ft.

iii) A total of about 15 million cubic yards of silty sand and a net (i.e. assuming 15% loss of during hydraulic dredging and placement) of about 12+ million cubic yards of silty sand is estimated to be available within the diked area.

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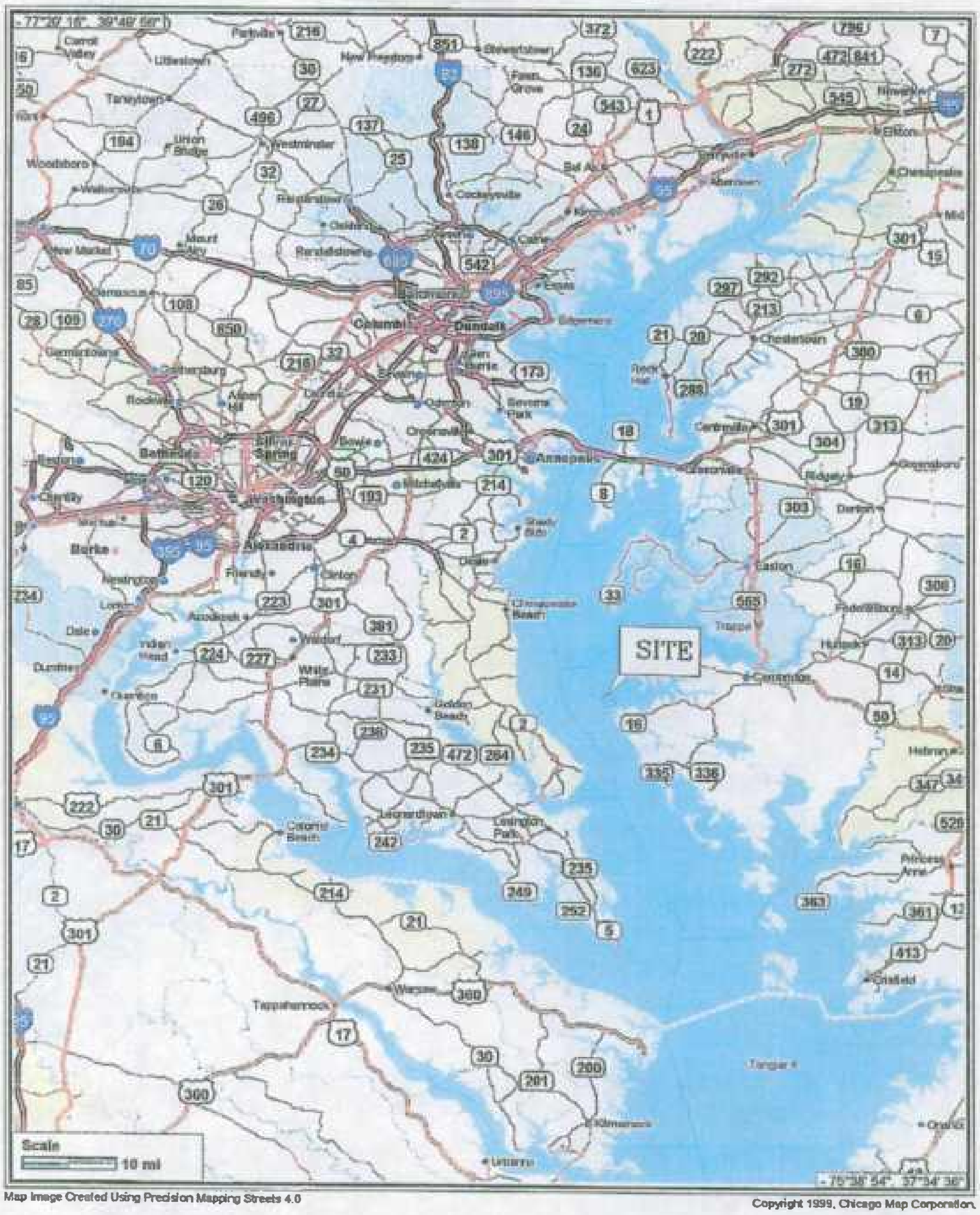
APPENDICES

Appendix A
Figures

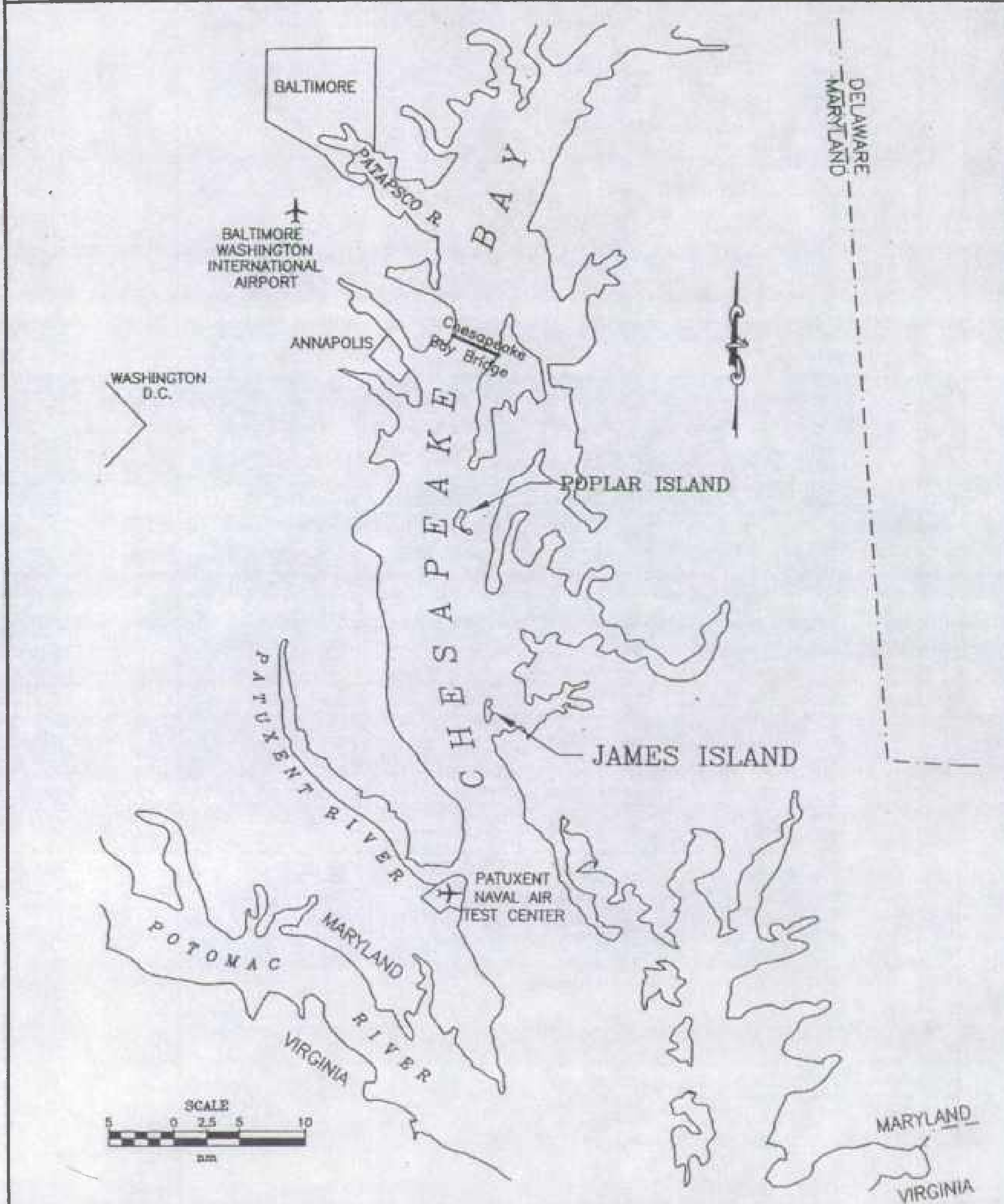
ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·	SITE VICINITY MAP JAMES ISLAND CHESAPEAKE BAY, MARYLAND		
	FIGURE: 1	DRAWN BY: NS	CHECKED BY:
	DATE: AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN

JAMES ISLAND



Map Image Created Using Precision Mapping Streets 4.0

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·	SITE LOCATION PLAN JAMES ISLAND CHESAPEAKE BAY, MARYLAND		
	FIGURE: 2	DRAWN BY: GVK	CHECKED BY:
	DATE: AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN



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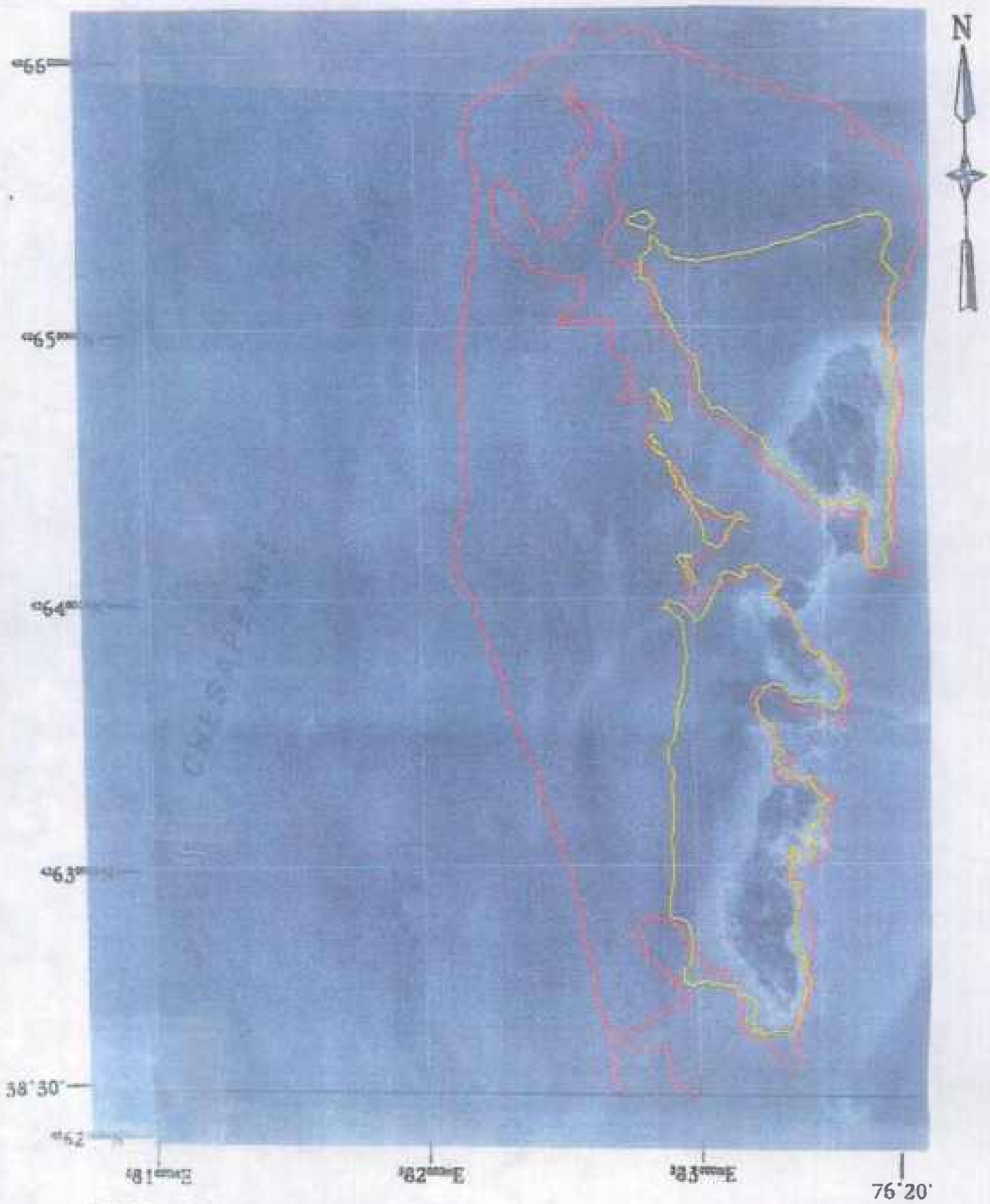
CONSTRUCTION · REMEDIATION ·

EXISTING CONDITIONS
JAMES ISLAND
CHESAPEAKE BAY, MARYLAND

FIGURE: 3	DRAWN BY: GVK	CHECKED BY:
DATE: AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN



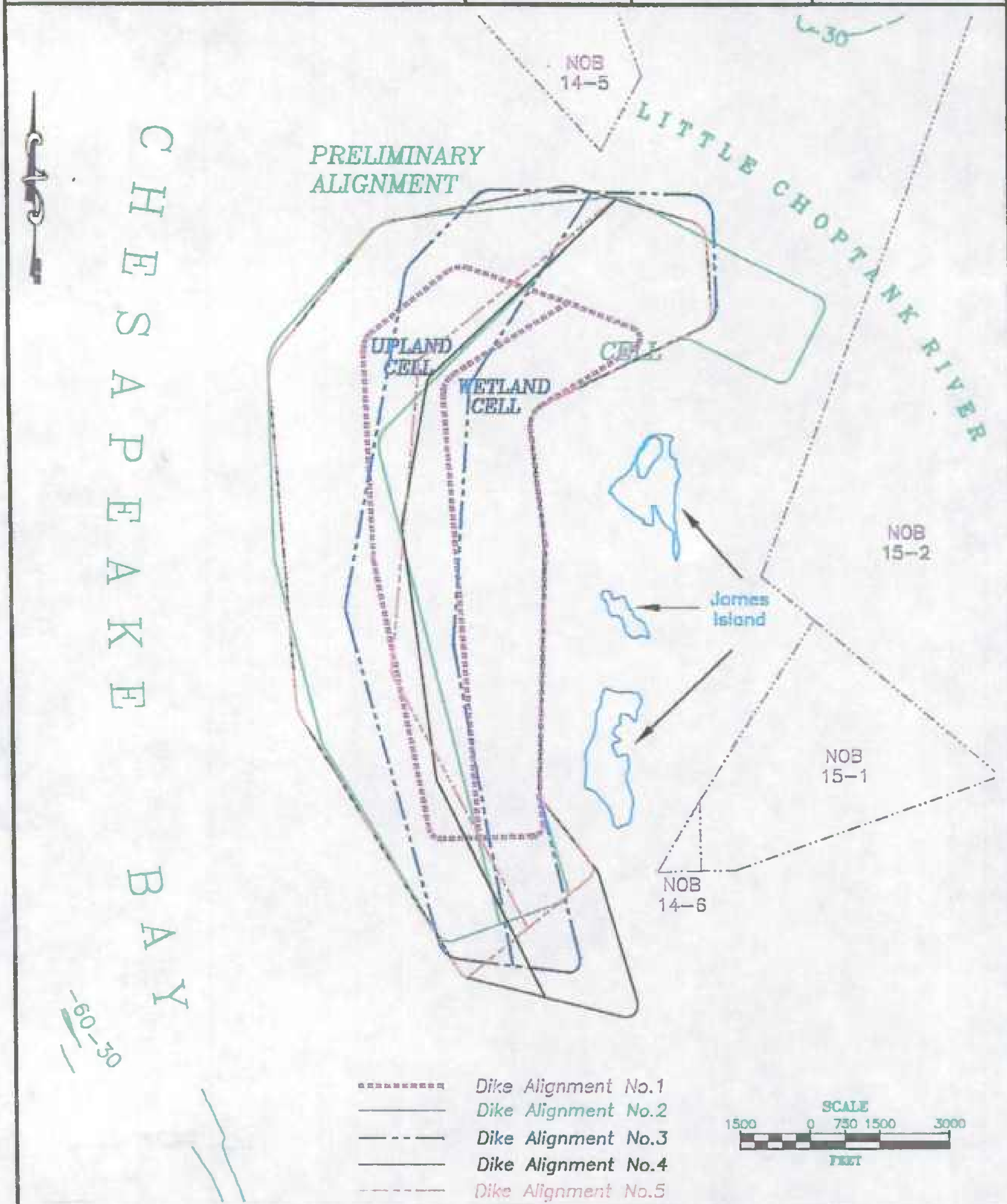
Scale: 1000 0 1000 2000 3000

1847 Shoreline

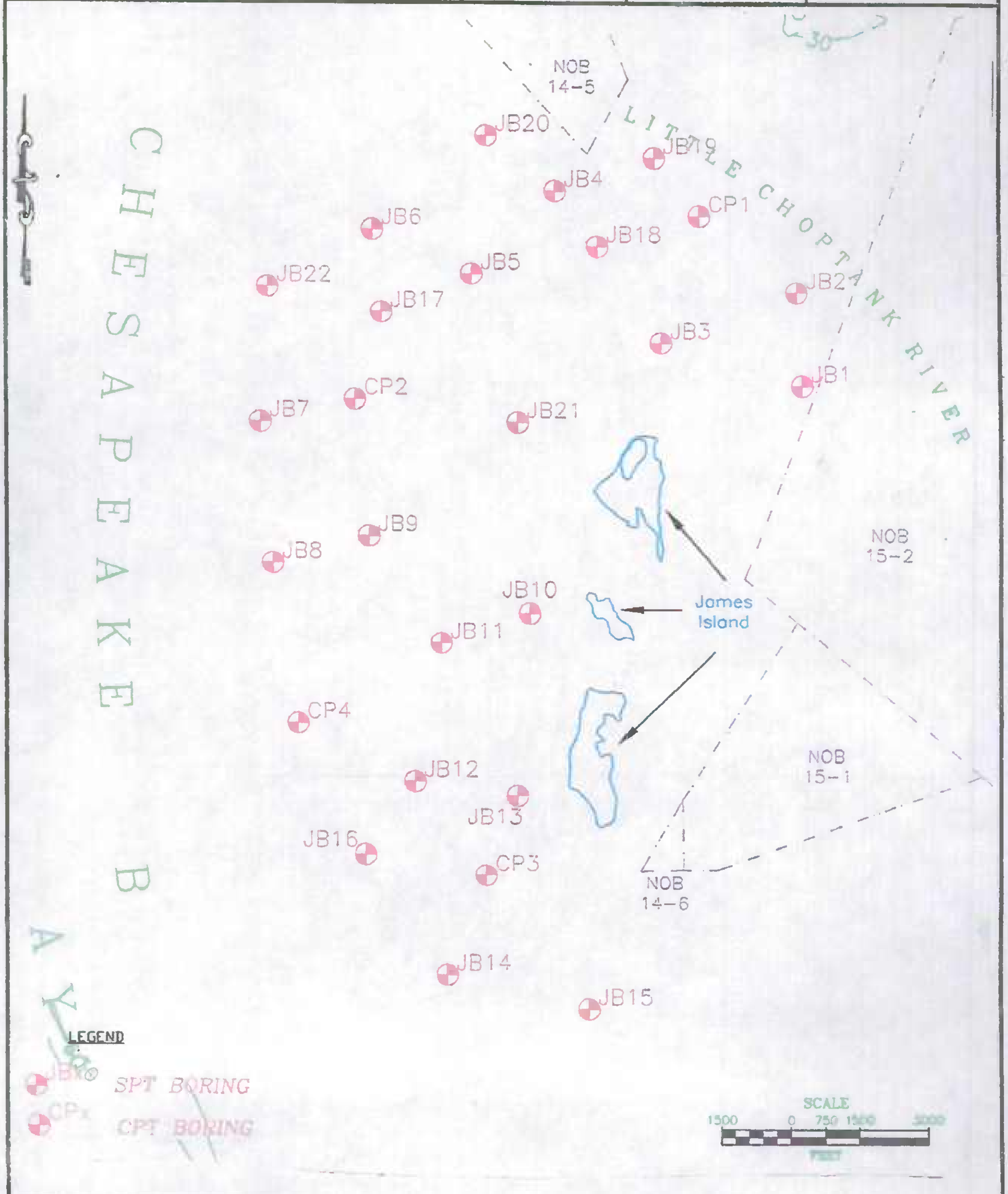
1942 Shoreline

Adapted from
Maryland Geological Survey (1997)
Date of Photography: April 1989

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·	ALTERNATE ALIGNMENTS JAMES ISLAND CHESAPEAKE BAY, MARYLAND	
FIGURE: 4	DRAWN BY: GVK	CHECKED BY:
DATE:AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN

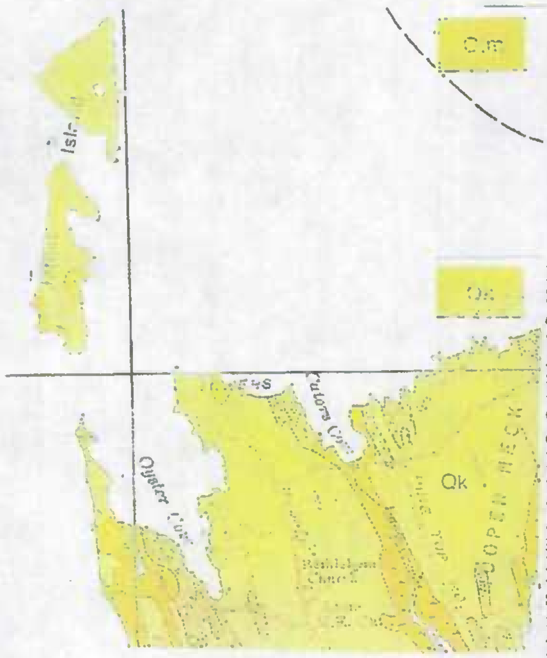


ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·	TEST BORING LOCATION PLAN JAMES ISLAND CHESAPEAKE BAY, MARYLAND	
FIGURE: 5	DRAWN BY: GVK	CHECKED BY:
DATE: AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN



ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·	**MGS GEOLOGICAL MAP** **JAMES ISLAND** **CHESAPEAKE BAY, MARYLAND**	
FIGURE: 6	DRAWN BY: GVK	CHECKED BY:
DATE: AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN

EXPLANATION OF MAP UNITS



TIDAL MARSH DEPOSITS (HOLOCENE) — Silt or clay, locally mixed with thin beds of sand, particularly near river mouths. Sediment is dark gray to gray brown due to abundant, finely comminuted, decayed organic matter, and is unconsolidated "soupy". Tidal marsh deposits are widespread in the southern part of the County. The largest area extends from the Blackwater National Wildlife Refuge eastward for about 22 km (14 mi) to the Nanticoke River and ranges in width from about 3 to 13 km (2 to 8 mi). Sediment thickness is unknown. In nearby areas, thicknesses up to about 6 m (20 ft) have been reported (Owens and Denny, 1978, 1979a).

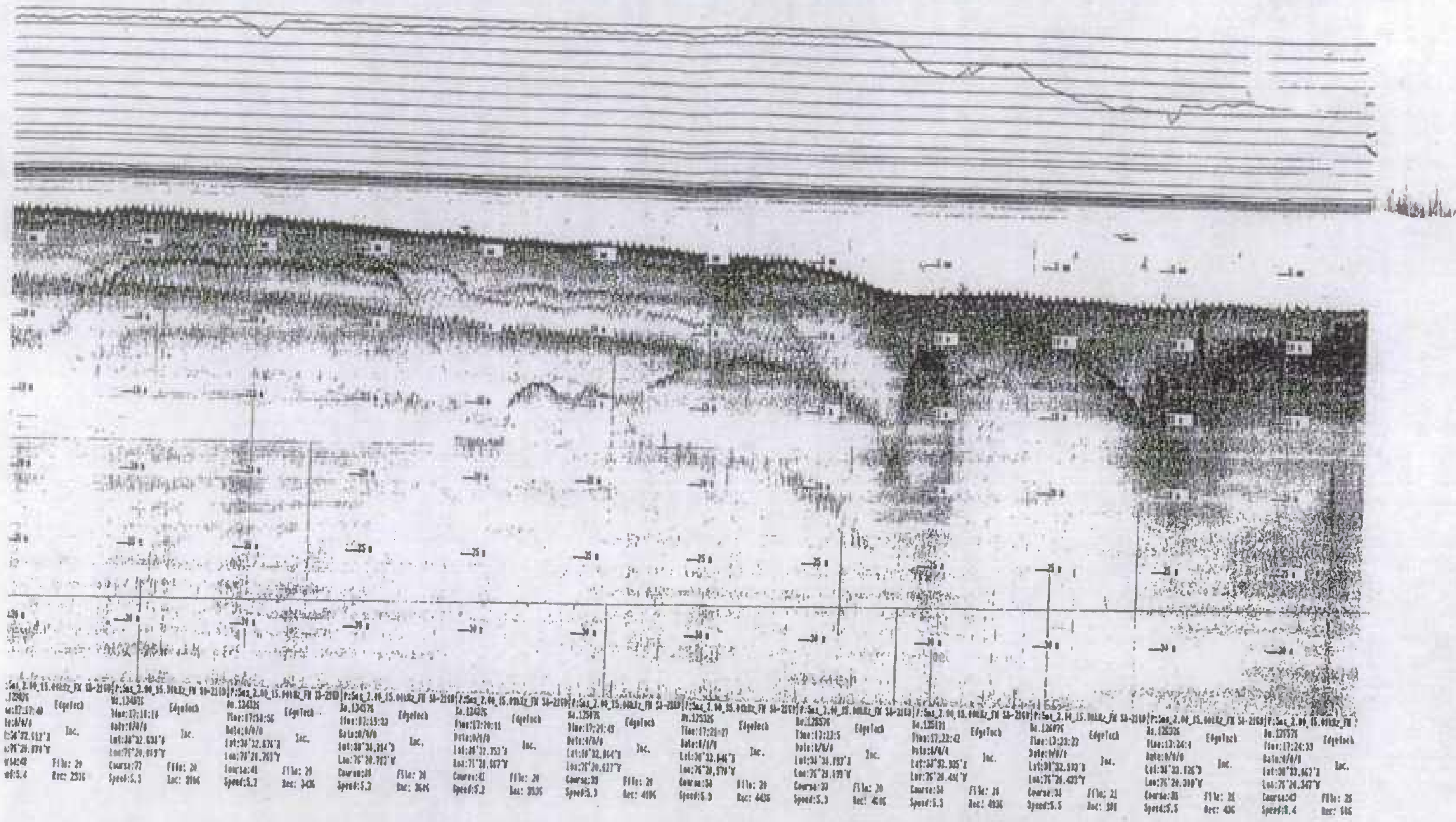
KENT ISLAND FORMATION (MIDDLE WISCONSIN OR UPPER SANGAMON) — Interbedded silt, clay, and sand, with abundant organic matter in places. Clayey and silty sediments underlie most of Dorchester County except the northeastern part where sandy and, in places, gravelly materials overlie the Beaverdam Sand or the Pensauken Formation. In the central County, the Kent Island Formation forms an essentially featureless plain that slopes southward from a low drainage divide just south of the Choptank River and the uplands to the east. The Kent Island plain is traversed by several south-flowing streams, such as the headwaters of the Blackwater River, the Transquaking River, and the Chicamacomico River, which are separated by broad flat areas with poorly-drained soils. The Formation underlies a broad lowland (maximum width 45 km or 38 mi) that is part of a plain extending for nearly 200 km (125 mi) along the east side of Chesapeake Bay. A west-facing scarp with a toe at an altitude of about 7 m (25 ft) separates this lowland from higher land to the east. In Dorchester County, this scarp is not as prominent a topographic feature as it is to the north of the Choptank River.

Adjacent to Chesapeake Bay, in the southwestern County, the Kent Island Fm. underlies long, narrow areas separated by tidal marsh. The nature of the sediments composing the Kent Island in this coastal belt is largely unknown, but the striped appearance of the belt suggests that it is part of a barrier-back barrier system. The broad area of tidal marsh farther northeast, including the Blackwater National Wildlife Refuge, appears to occupy the back-barrier part of the same system. The inner edge of the tidal marsh to the northeast of the Blackwater Refuge trends in a west-northwest direction, whereas the coastal belt trends in a northwest direction. This change in trend suggests that the emplacement of the northwest trending deposits in the coastal belt took place after deposition of the west-northwest trending Kent Island Fm. in the rest of the County.

From Geologic Map of Dorchester County, MGS, 1986

In the belt bordering the Bay and the Honga River in the southwest County, the stipple pattern indicates areas of well-drained to moderately well-drained soils (Mathews, 1963) that are as much as 1 m (3 ft) above adjoining areas of poorly to very poorly-drained soils.

Scale 1:62500



Note: The survey was conducted by MGS on August 7, 2001

E2CR, INC.	SIDE SCAN SONAR PROFILE JAMES ISLAND	FIGURE: 7	DRAWN BY: GVK	CHECKED BY:
		DATE: AUG., 02	JOB NO.: 01572	SCALE:

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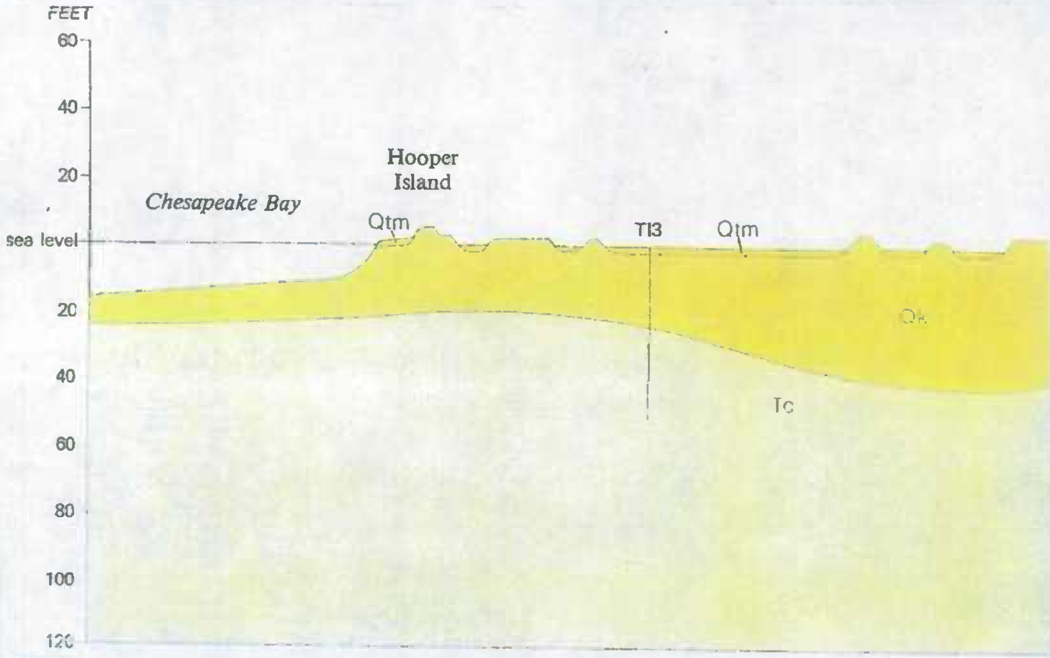
CONSTRUCTION · REMEDIATION ·

MGS GEOLOGICAL CROSS SECTION NEAR JAMES ISLAND CHESAPEAKE BAY, MARYLAND

FIGURE: 8	DRAWN BY: GVK	CHECKED BY:
DATE:AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN



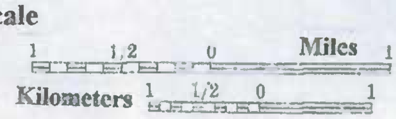
CHESAPEAKE GROUP, UNDIVIDED (older MIOCENE) — Subsurface unit shown only in cross-section. Outcrops along the Choptank River west of Cambridge as interbedded loose micaceous sand, dark silt, and clay (Miller, 1912). In Wicomico County to the southeast, laterally adjacent materials in the subsurface are included in the "Yorktown(?) and Cohansey(?)" Formations (Owens and Denny, 1979a). The location and nature of the contact between these two units are unknown.

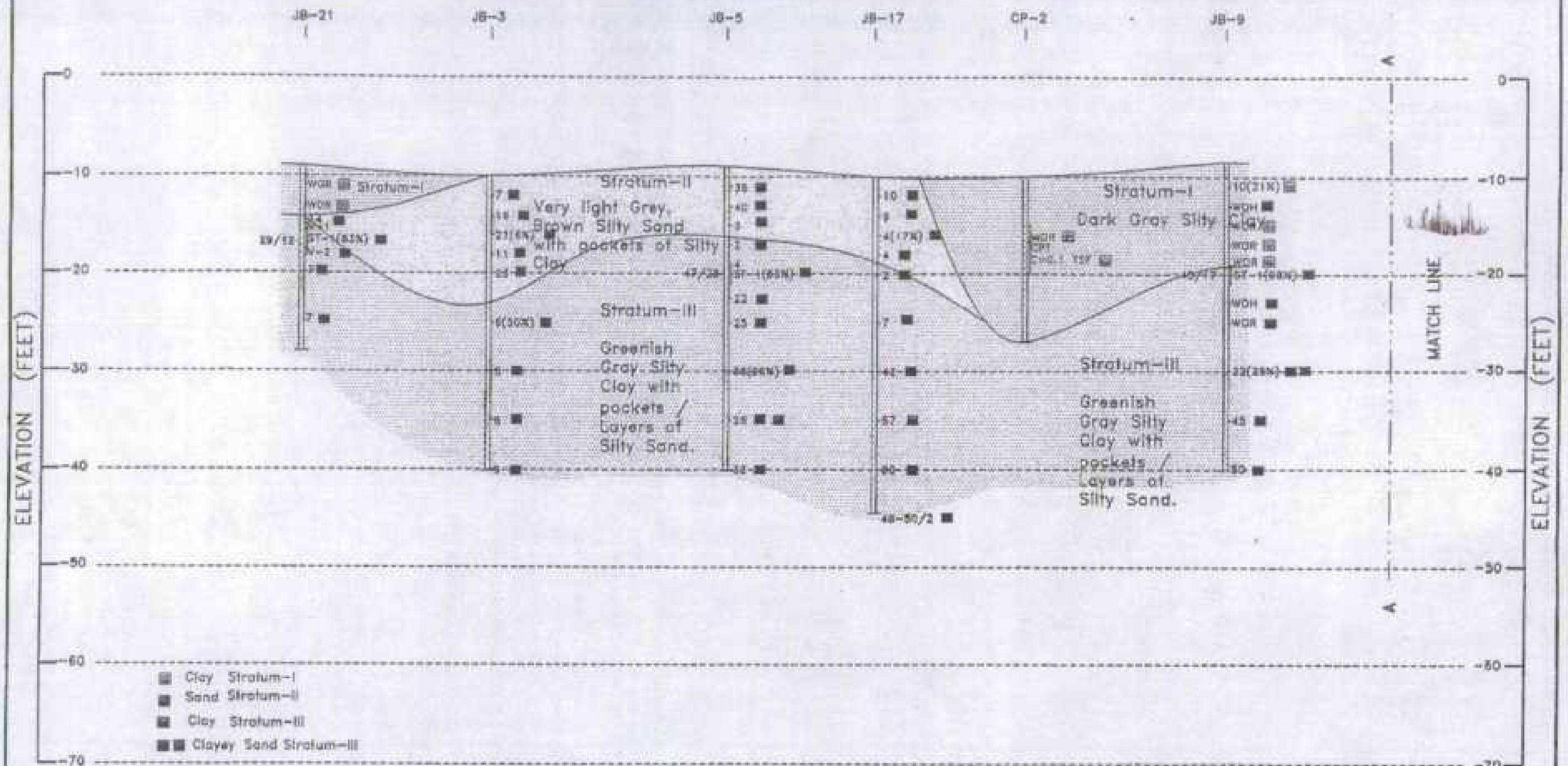
**Editor's note:* Hansen (1981) has argued that the Pensauken overlies the "Yorktown(?) and Cohansey(?)" Formations unconformably and is, therefore a younger unit, perhaps coeval in part with the Beaverdam Formation. He noted that in central Wicomico County, near Salisbury, Pensauken channel-fill deposits trench through the "Yorktown(?) and Cohansey(?)" Formations and rest directly on the underlying St. Marys Formation of Rasmussen and Slaughter (1955).

KENT ISLAND FORMATION (MIDDLE WISCONSIN OR UPPER SANGAMON) — Interbedded silt, clay, and sand, with abundant organic matter in places. Clayey and silty sediments underlie most of Dorchester County except the northeastern part where sandy and, in places, gravelly materials overlie the Beaverdam Sand or the Pensauken Formation. In the central County, the Kent Island Formation forms an essentially featureless plain that slopes southward from a low drainage divide just south of the Choptank River and the uplands to the east. The Kent Island plain is traversed by several south-flowing streams, such as the headwaters of the Blackwater River, the Transquaking River, and the Chicamacomico River, which are separated by broad flat areas with poorly-drained soils. The Formation underlies a broad lowland (maximum width 45 km or 38 mi) that is part of a plain extending for nearly 200 km (125 mi) along the east side of Chesapeake Bay. A west-facing scarp with a toe at an altitude of about 7 m (25 ft) separates this lowland from higher land to the east. In Dorchester County, this scarp is not as prominent a topographic feature as it is to the north of the Choptank River.

From Geologic Map of Dorchester County, MGS, 1986

Scale





LEGEND

- JB – Boring Number
- CP – Cone Penetration Boring Number
- WOR – Weight of Rod
- WOH – Weight of Hammer
- 10 – Standard Penetration Resistance, Blows/foot
- – Water surface elevation
- (82%) – Percentage Fines
- 66/38 – Liquid Limit/Plasticity Index
- ST – Shelby Tube
- V – Vane Shear
- C – Cohesion

VERTICAL SCALE

10 0 5 10 20

FEET

JAMES ISLAND

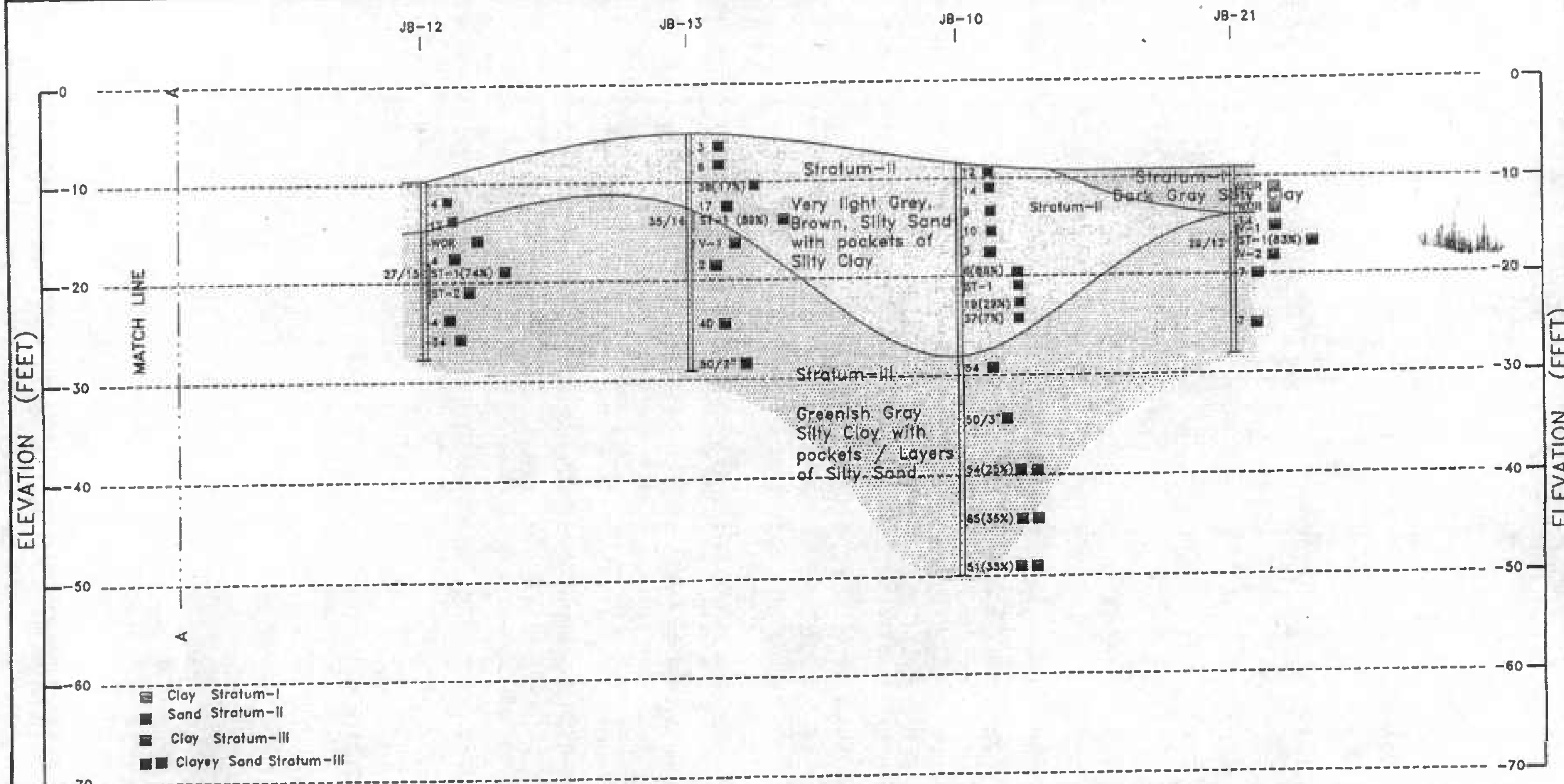
DIKE ALIGNMENT 1

HORIZONTAL SCALE

1500 0 750 1500 3000

FEET

E2CR, INC.	GENERALIZED SUBSURFACE PROFILE	FIGURE: 9 a	DRAWN BY: GVK	CHECKED BY: SB
		DATE: AUG., 2002	JOB NO.: 01573-04	SCALE: As Shown



LEGEND

JB - Boring Number
CP - Cone Penetration Boring Number
WOR - Weight of Rod
WOH - Weight of Hammer
10 - Standard Penetration Resistance, Blows/foot
- Water surface elevation
(22%) - Percentage Fines
66/36 - Liquid Limit/Plasticity Index
ST - Shelby Tube
V - Vane shear
C - Cohesion

VERTICAL SCALE

10 0 5 10 20

FEET

JAMES ISLAND

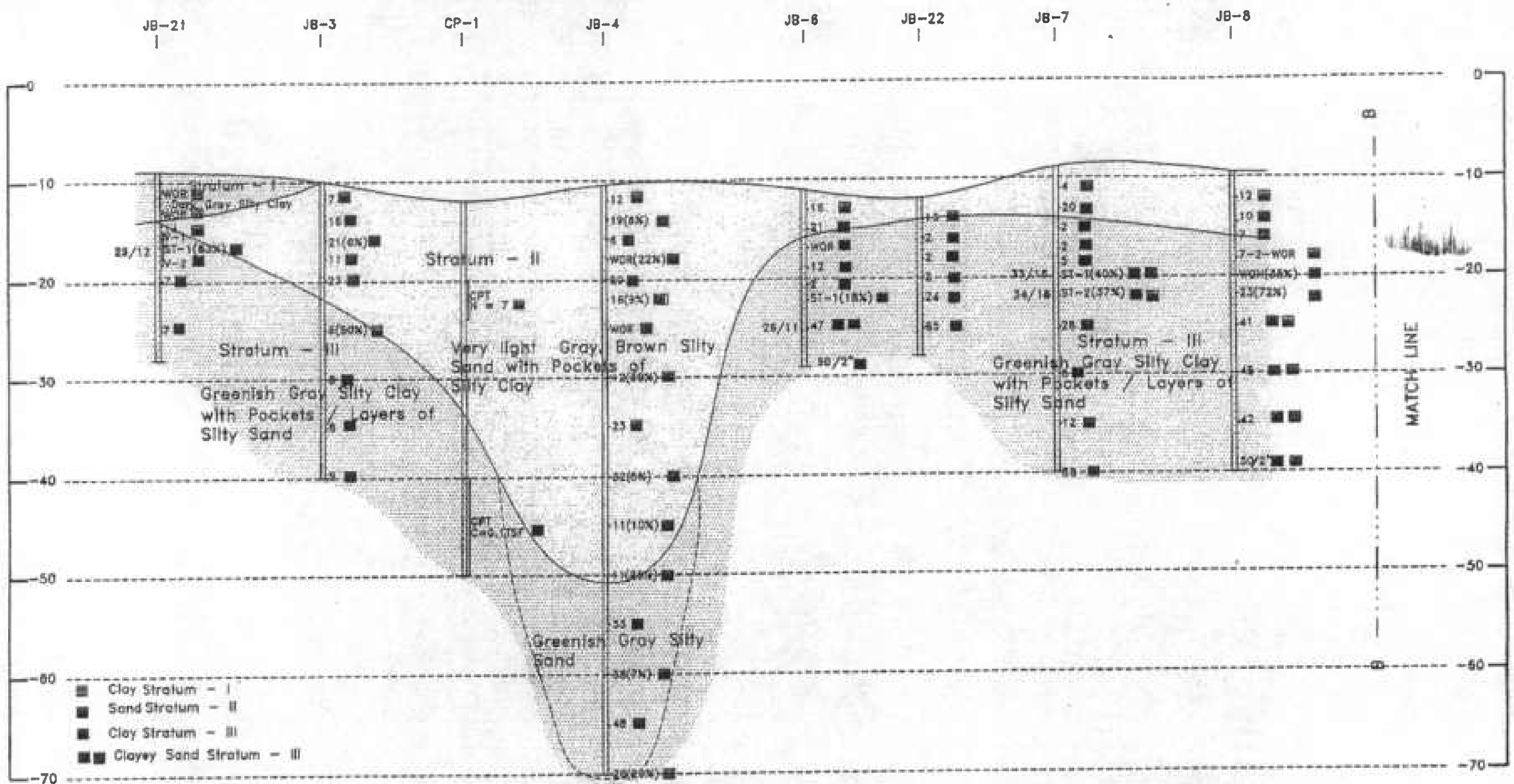
DIKE ALIGNMENT 1

HORIZONTAL SCALE

1500 0 750 1500 3000

FEET

E2CR, INC.	GENERALIZED SUBSURFACE PROFILE	FIGURE: 9 b	DRAWN BY: GVK	CHECKED BY: SB
		DATE: AUG., 2002	JOB NO.: 01572-04	SCALE: As Shown



LEGEND

JB - Boring Number
CP - Cone Penetration Boring Number
WOR - Weight of Rod
WOH - Weight of Hammer
10 - Standard Penetration Resistance, Blows/foot
- Water surface elevation
(22%) - Percentage Fines
66/38 - Liquid Limit/Plasticity Index
ST - Shelby Tube
V - Vane Shear
C - Cohesion

VERTICAL SCALE

10 0 5 10 20

FEET

JAMES ISLAND

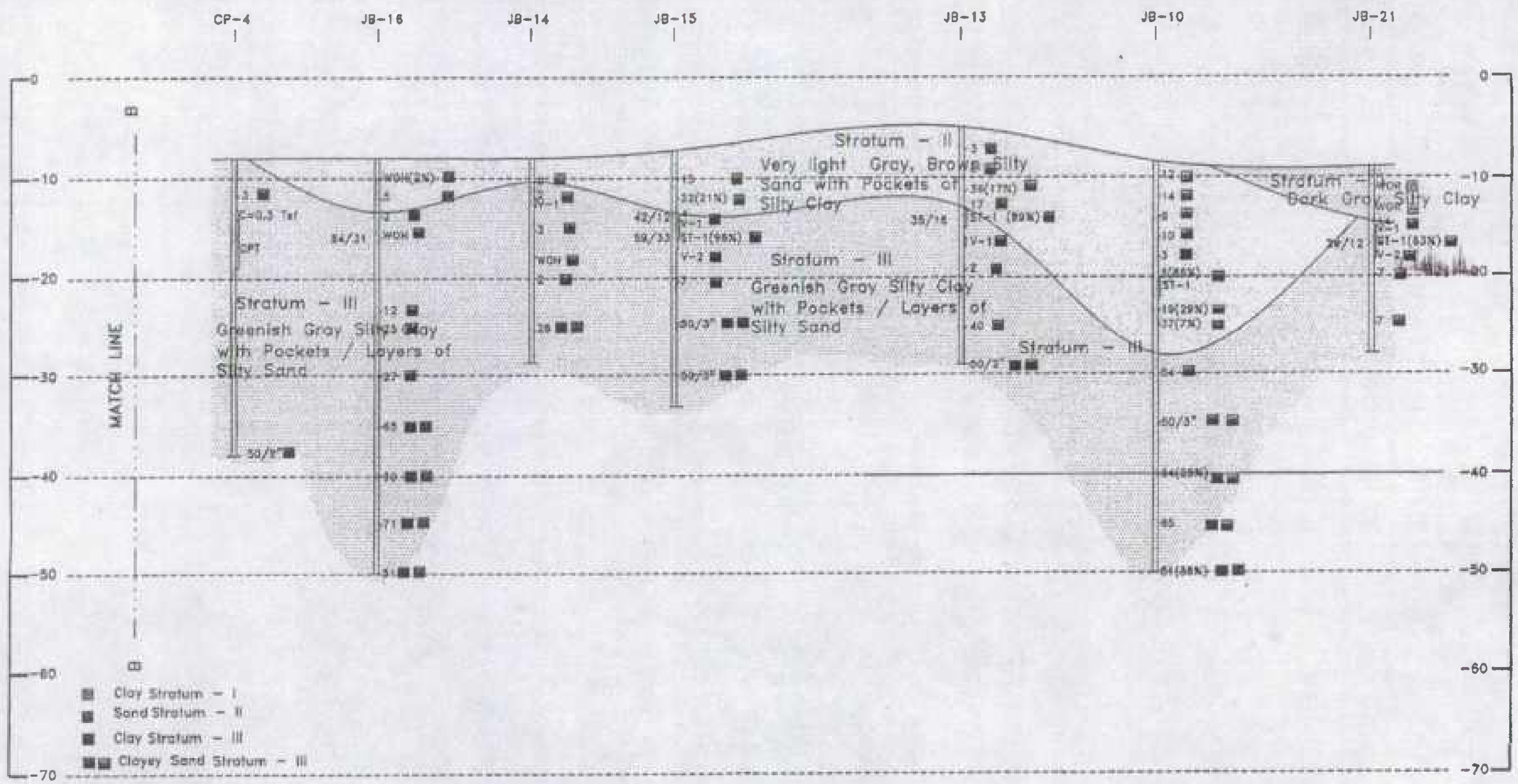
DIKE ALIGNMENT 4

HORIZONTAL SCALE

1500 0 750 1500 3000

FEET

E2CR, INC.	GENERALIZED SUBSURFACE PROFILE	FIGURE: 10 a	DRAWN BY: GVK	CHECKED BY: SB
		DATE: AUG., 02	JOB NO.: 01572-04	SCALE: As Shown



LEGEND

- JB - Boring Number
- CP - Cone Pentration Boring Number
- WOR - Weight of Rod
- WOH - Weight of Hammer
- 10 - Standard Penetration Resistance, Blows/foot
- Water surface elevation
- (22%) - Percentage Fines
- 66/38 - Liquid Limit/Plasticity Index
- ST - Shelby Tube
- V - Vane Shear
- C - Cohesion

VERTICAL SCALE

10 0 5 10 20

FEET

JAMES ISLAND

DIKE ALIGNMENT 4

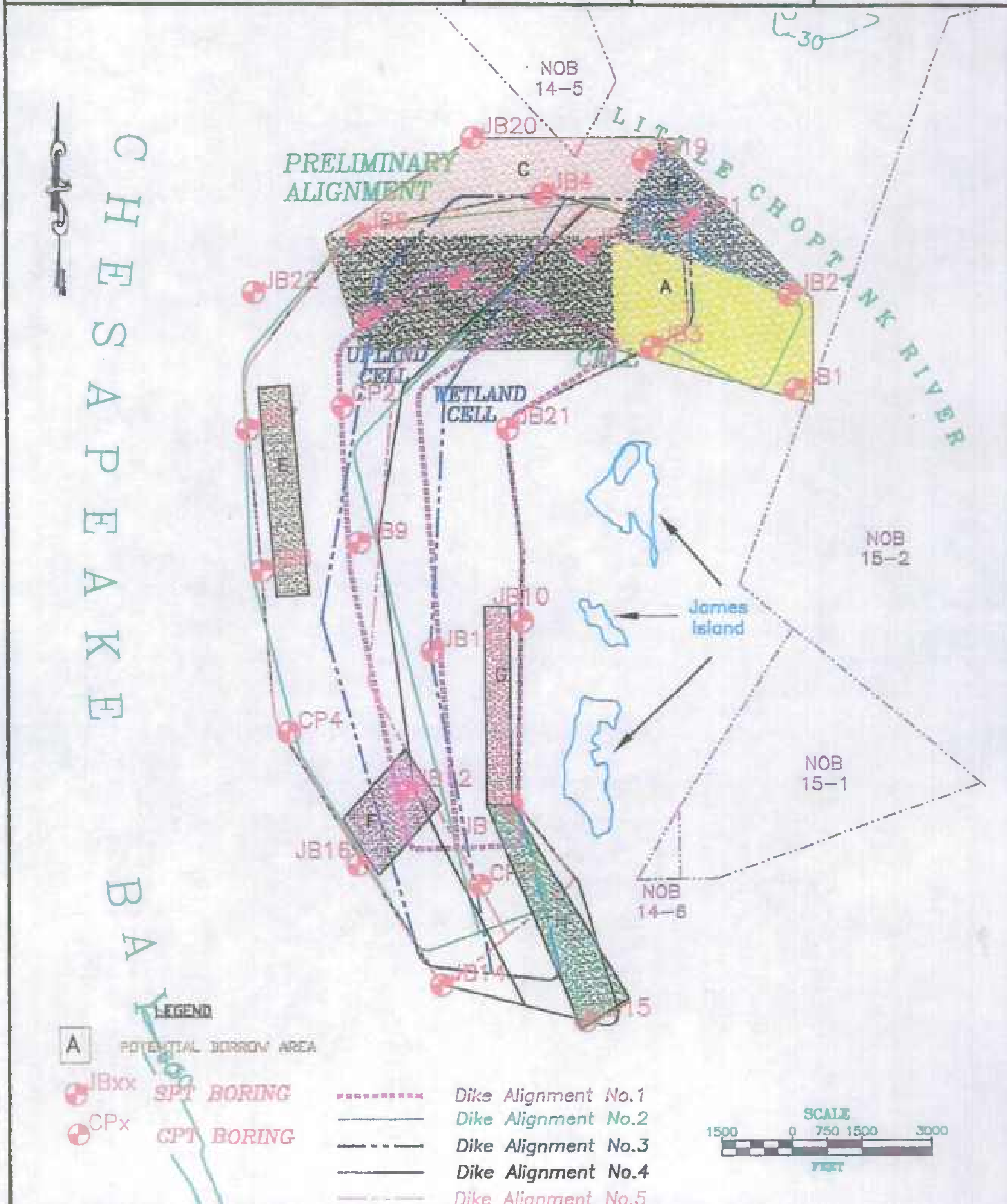
HORIZONTAL SCALE

1500 0 750 1500 3000

FEET

E2CR, INC.	GENERALIZED SUBSURFACE PROFILE	FIGURE: 10 b	DRAWN BY: GVK	CHECKED BY: SB
		DATE: AUG., 2002	JOB NO.: 01572-04	SCALE: As Shown

ENGINEERING · CONSULTATION · E2C/R inc. CONSTRUCTION · REMEDIATION ·	LOCATION OF POTENTIAL BORROW AREAS JAMES ISLAND, CHESAPEAKE BAY, MARYLAND		
	FIGURE: 11	DRAWN BY: GVK	CHECKED BY:
	DATE: AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN



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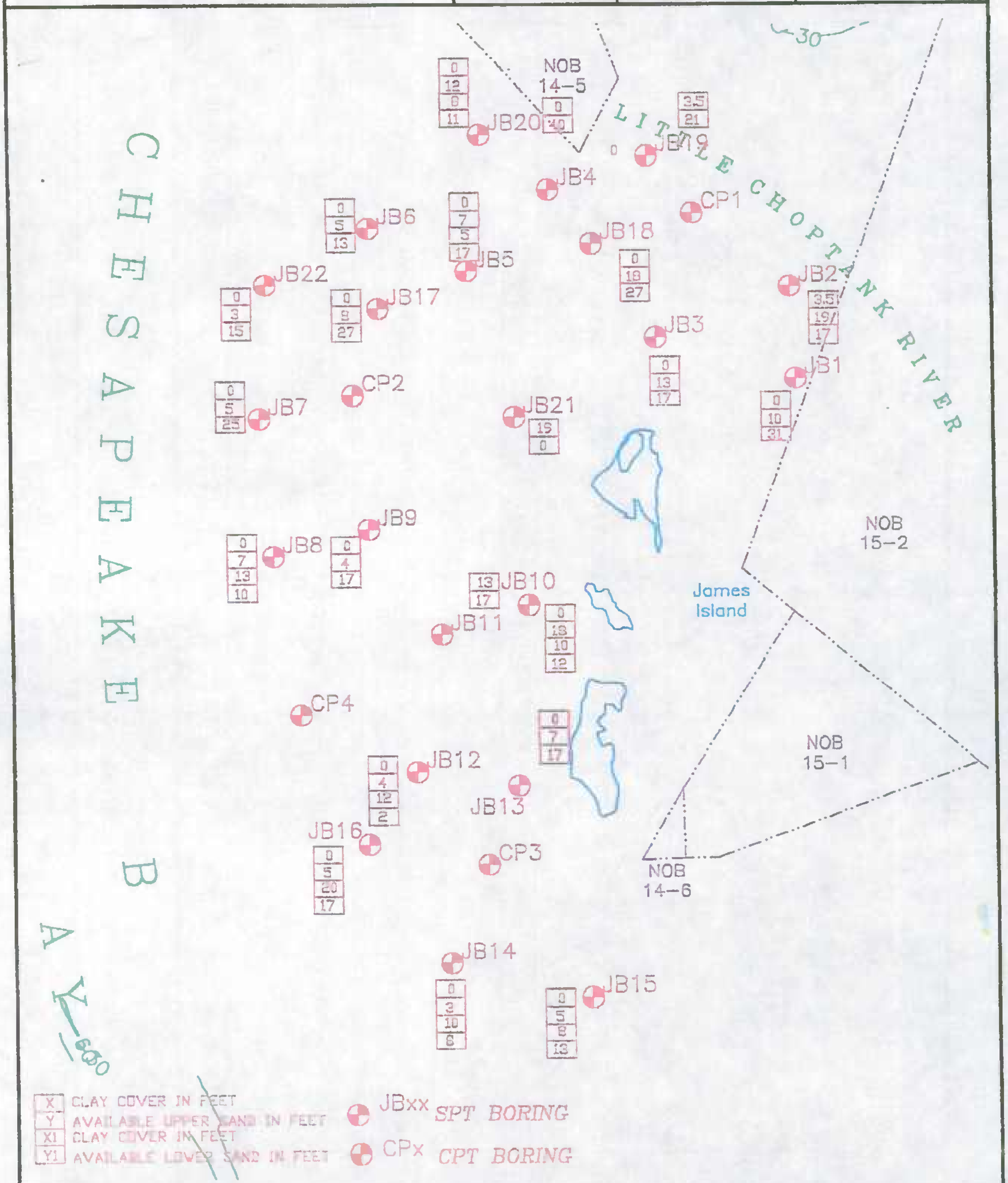
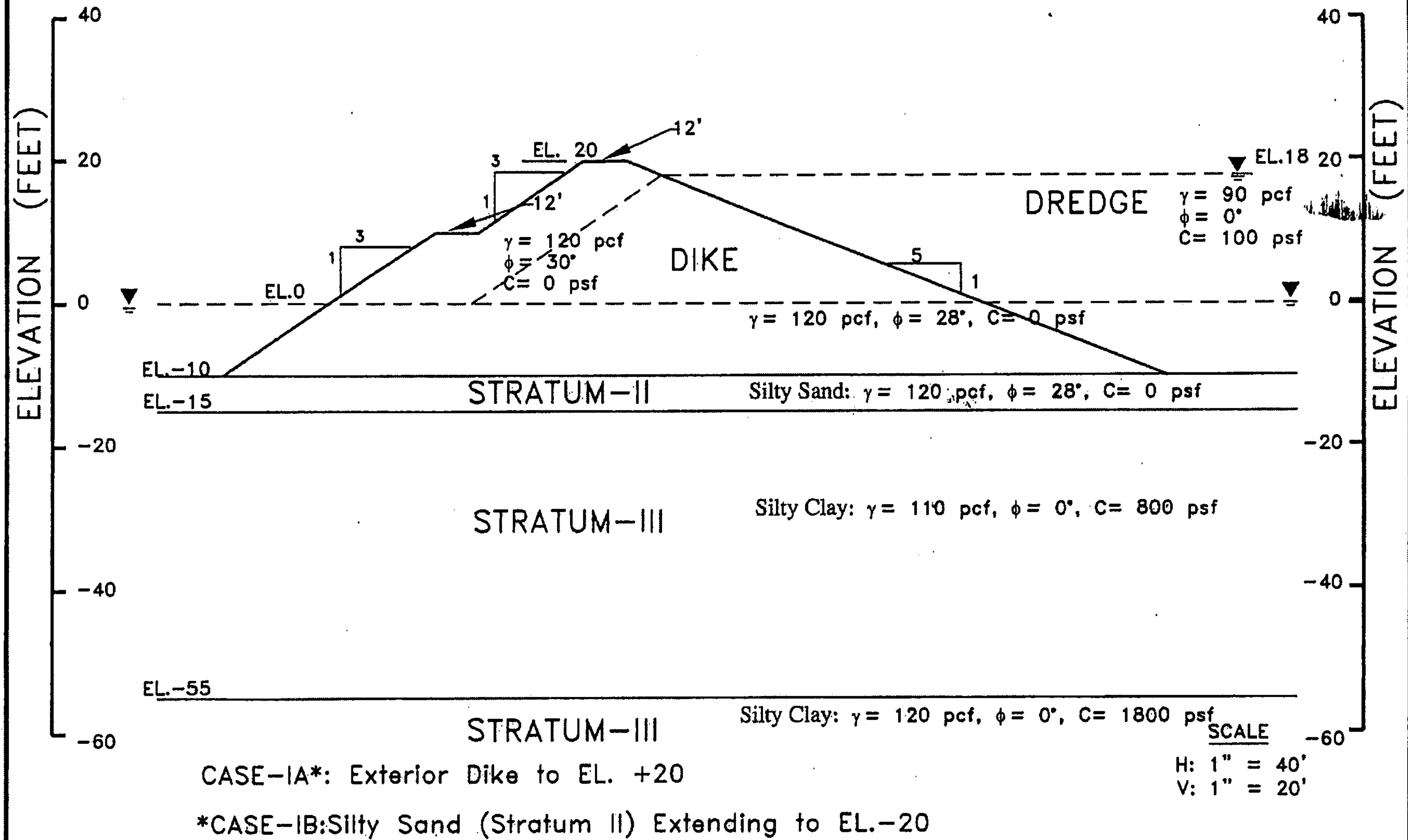
CONSTRUCTION · REMEDIATION ·

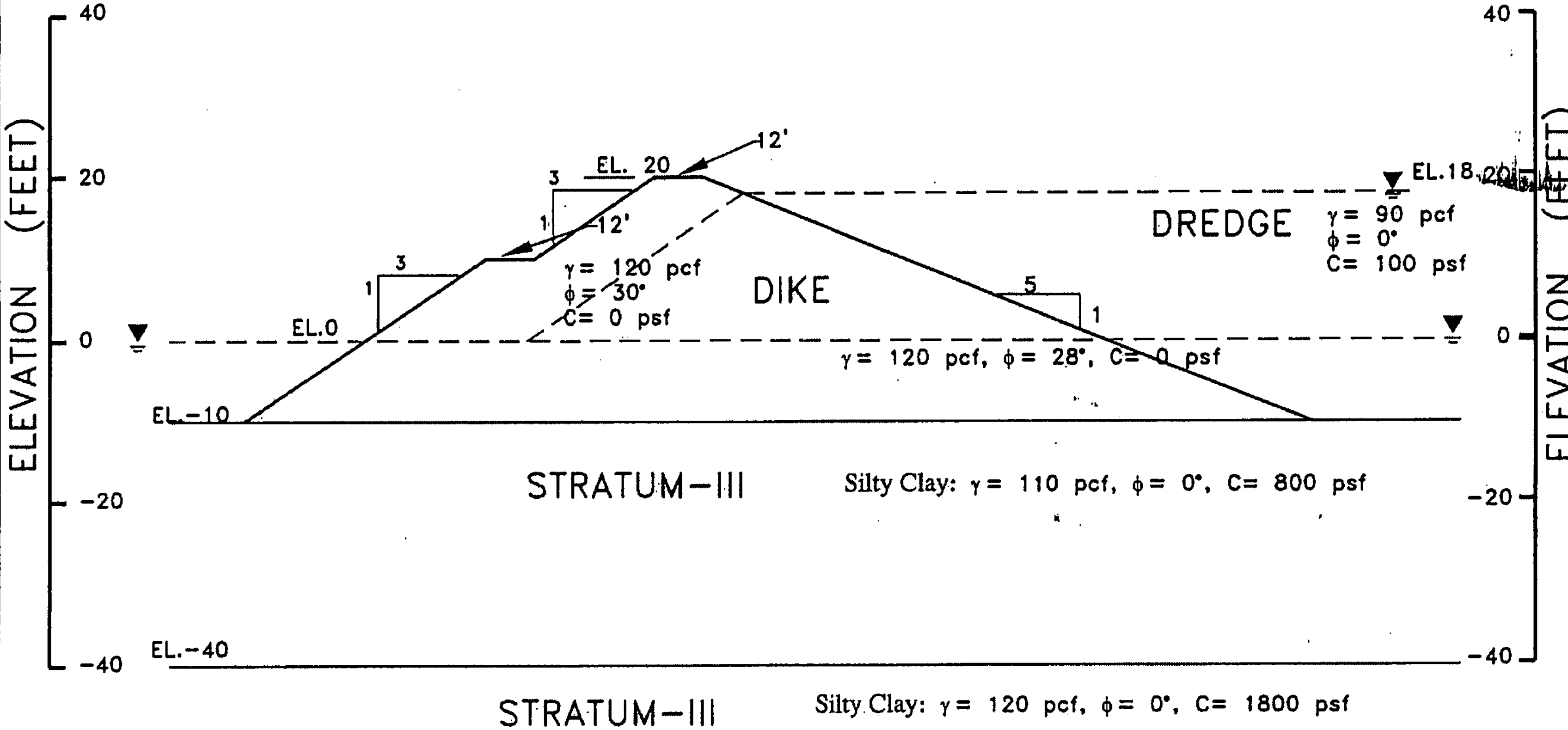
THICKNESS OF CLAY AND SAND-BORROW AREAS
JAMES ISLAND, CHESAPEAKE BAY, MARYLAND

FIGURE: 12	DRAWN BY: GVK	CHECKED BY:
DATE: AUG., 02	JOB NO: 01572-04	SCALE: AS SHOWN





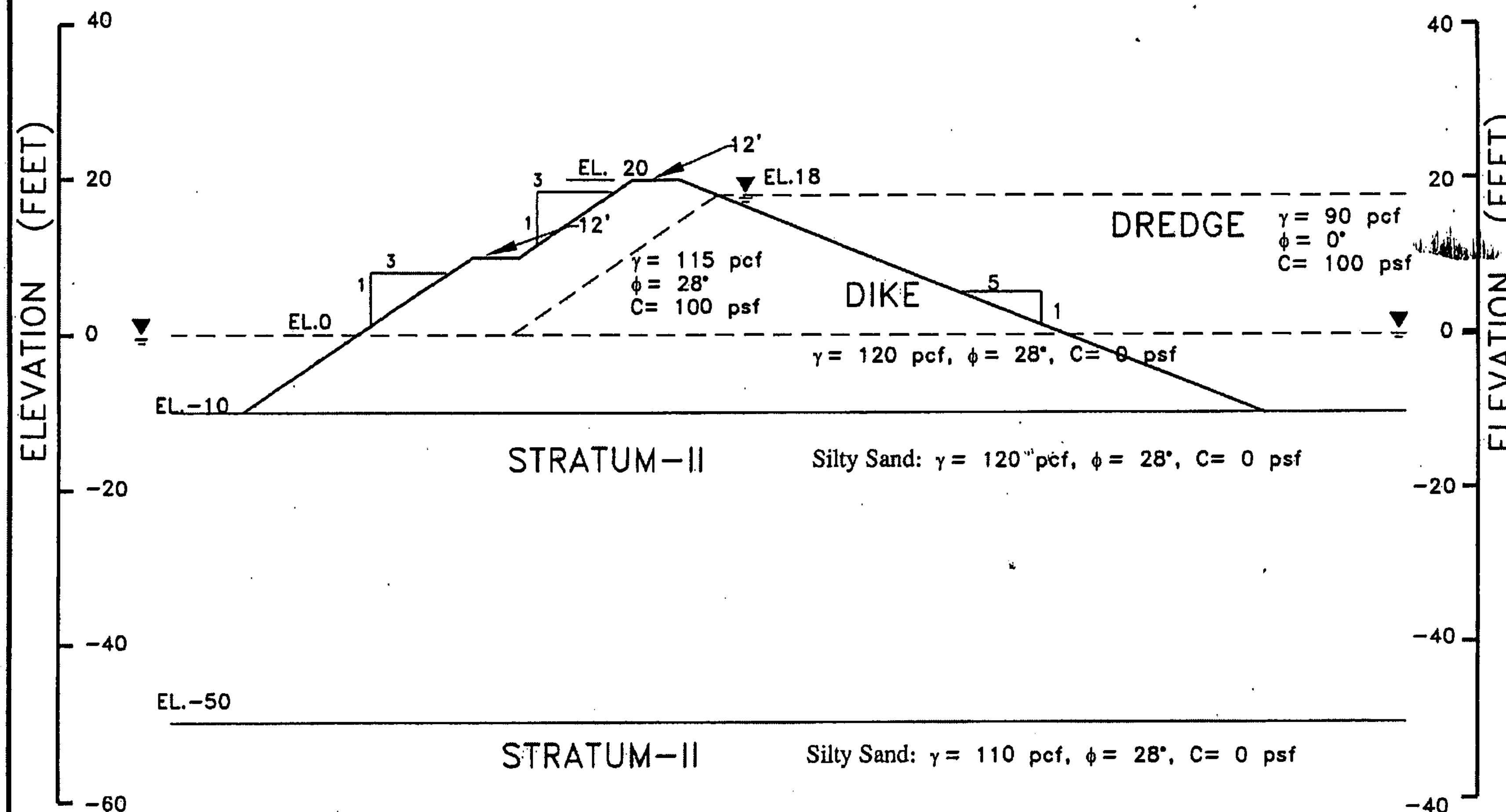
E2CR, INC.	JAMES ISLAND SLOPE STABILITY ANALYSIS Exterior Dike to EL. +20 : Case- 1	FIGURE: 13a	DRAWN BY: AS	CHECKED BY: GVK
		DATE: AUG.,2002	JOB NO.: 01572	SCALE: As Shown



CASE-2: Exterior Dike to EL. +20

SCALE
H: 1" = 40'
V: 1" = 20'

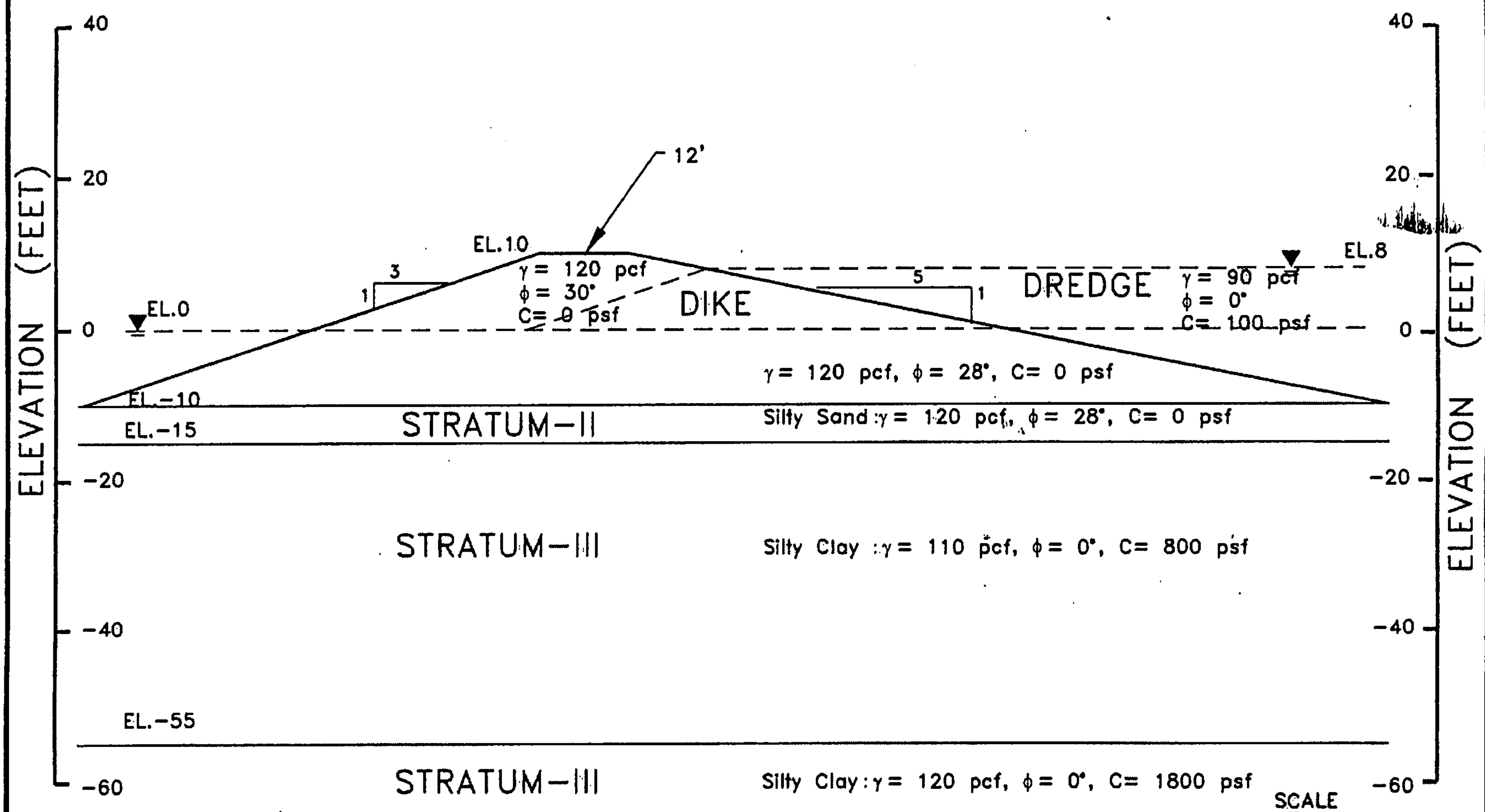
E2CR, INC.	JAMES ISLAND SLOPE STABILITY ANALYSIS Exterior Dike to EL. +20: Case-2	FIGURE: 13b	DRAWN BY: AS	CHECKED BY: GVK
		DATE: AUG.,2002	JOB NO.: 01572	SCALE: As Shown



CASE-3: Exterior Dike to EL. +20

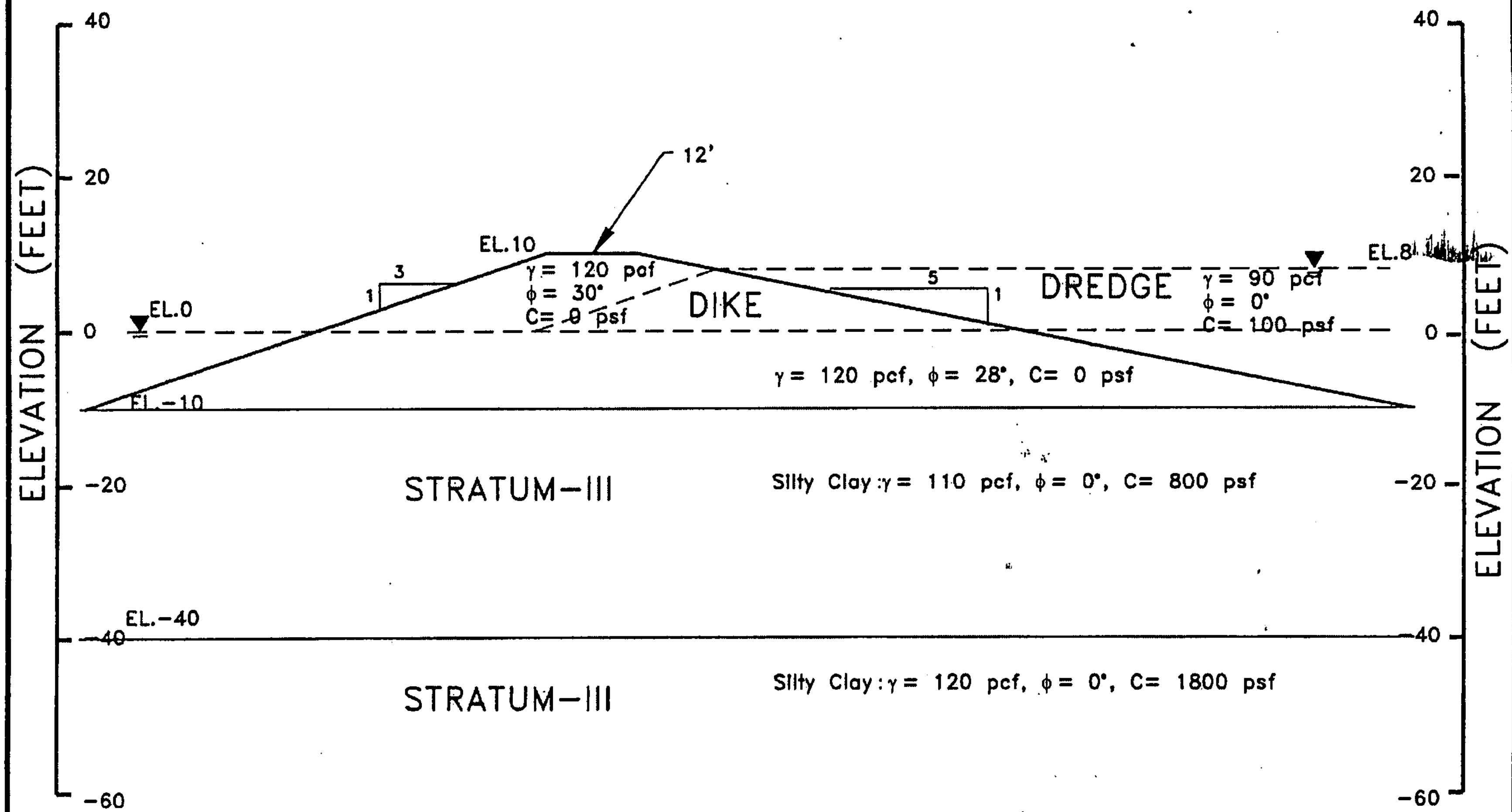
SCALE
H: 1" = 40'
V: 1" = 20'

E2CR, INC.	JAMES ISLAND SLOPE STABILITY ANALYSIS Exterior Dike to EL. +20 :Case-3	FIGURE: 13c	DRAWN BY: AS	CHECKED BY: GVK
		DATE: AUG.,2002	JOB NO.: 01572	SCALE: As Shown



CASE-1A*: Exterior Dike to EL. +10
*CASE-1B: Silty Sand (StratumII) Extending to EL. -20

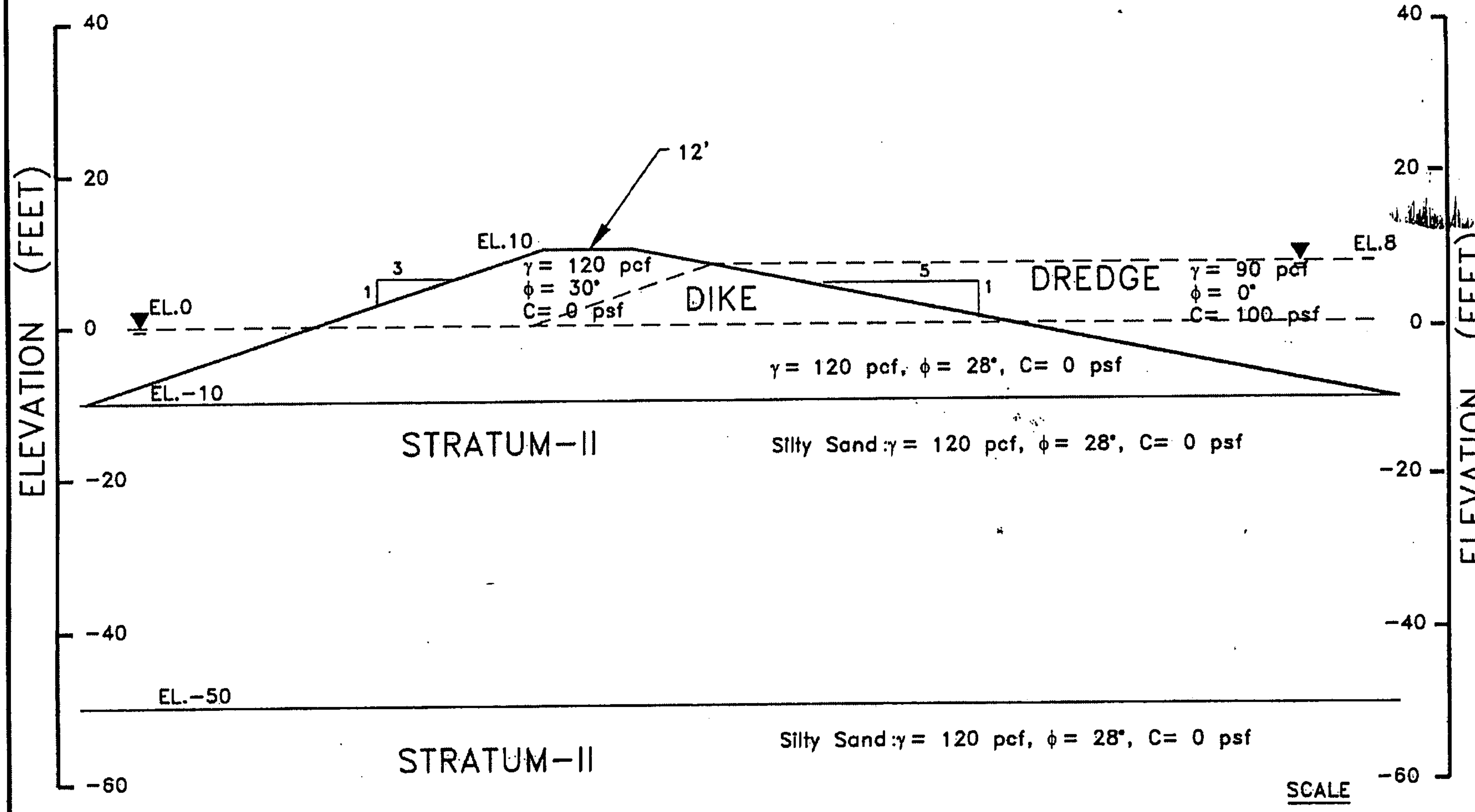
E2CR, INC.	JAMES ISLAND SLOPE STABILITY ANALYSIS Exterior Dike to EL. +10 :Case-1	FIGURE: 14a	DRAWN BY: AS	CHECKED BY: GVK
		DATE: AUG., 02	JOB NO.: 01552	SCALE: As Shown



CASE-2: Exterior Dike to EL. +10

SCALE
H: 1" = 20'
V: 1" = 20'

E2CR, INC.	JAMES ISLAND SLOPE STABILITY ANALYSIS Exterior Dike to EL. +10 : Case-2	FIGURE: 14b	DRAWN BY: AS	CHECKED BY: GVK
		DATE: AUG., 02	JOB NO.: 01552	SCALE: As Shown



CASE-3: Exterior Dike to EL. +10

E2CR, INC.	JAMES ISLAND SLOPE STABILITY ANALYSIS Exterior Dike to EL. +10 : Case-3	FIGURE: 14c	DRAWN BY: AS	CHECKED BY: GVK
		DATE: AUG., 02	JOB NO.: 01552	SCALE: As Shown

Appendix B
Tables

ENGINEERING · CONSULTATION · E2CR inc CONSTRUCTION · REMEDIATION ·

TABLE-1: ENCLOSED AREA ALONG CENTERLINE OF ALIGNMENT

James Island
E2CR Project No. 01572-04

Case	Enclosed area (Acres)
Dike Alignment No.1	978
Dike Alignment No.2	2,126
Dike Alignment No.3	1,586
Dike Alignment No.4	2,200
Dike Alignment No.5	2,072

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TABLE-2: Depth of Borings
James Island
E2CR Project No. 01572-04

Note : * Depth from the existing water surface at El. 0.00

Boring	Depth of water (feet) at the time of drilling	Depth (feet) of boring from water surface*
JB-1	9.0	50.0
JB-2	10.5	50.0
JB-3	10.0	40.0
JB-4	10.5	70.0
JB-5	9.0	40.0
JB-6	11.0	29.0
JB-7	9.0	40.0
JB-8	9.5	40.0
JB-9	8.5	40.0
JB-10	8.5	50.0
JB-11	10.0	40.0
JB-12	9.5	27.5
JB-13	5.0	29.0
JB-14	8.0	28.5
JB-15	7.5	33.0
JB-16	8.0	50.0
JB-17	10.0	44.5
JB-18	9.0	56.0
JB-19	14.5	50.0
JB-20	14.0	45.0
JB-21	9.0	28.0
JB-22	12.0	28.0

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TABLE-3: SUMMARY OF LABORATORY AND VANE SHEAR TEST RESULTS

James Island

E2CR Project No. 01572-04

Note : * Depth from the existing water surface at El. 0.00

* * See the enclosed Unified Soil Classification System

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			UNCONFINED COMPRESSION Cu (PSF)	SHEAR STRENGTH		FIELD VANE SHEAR STRENGTH			USCS CLASSIFICATION**	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)		PENETRO QP(PSF)	TORVANE TV(PSF)	UNDISTURBED (PSF)	REMOLDED (PSF)	SENSITIVITY		
JB-1	S-3	13.0-15.0	31.7				82	18							SM	II
	S-5	18.0-20.0	83.5													III
	S-6	23.5-25.0	53.6													III
	S-7	28.5-30.0	43.9													III
	S-8	33.5-35.0	80.5	42	15										ML	III
	S-9	43.5-45.0	70.9													III
	S-10	48.5-50	69.8							150	220					III
JB-2	S-1	10.5-12.0	37.5													I
	S-7	23.5-25.0	19.3					16							SM	II
	S-9	33.5-35.0	36.2							500	600					III
	S-10	38.5-40.0	40.9							750	420					III
	S-11	43.5-45.0	42.4													III
	S-12	48.5-50.0	54.8	52	28					850	540				CH	III
JB-3	S-3	13.0-15.0	23.1				94	6							SP-SM	II
	S-8	23.5-25.0	28.4					50							CL	III
	S-7	28.5-30.0	43.8							500	500					III
	S-8	33.5-35.0	38.4							750	900					III
	S-9	38.5-40.0	50.0							750	950					III
JB-4	S-2	12.0-14.0	28.1				92	8							SP-SM	II
	S-4	18.0-18.0	25.1					22							SC	II
	S-5	20.0-22.0	25.3					9							SP-SM	II
	S-8	28.5-30.0	24.3					30							SM	II
	S-10	38.5-40.0	19.3				95	5							SP-SM	II
	S-11	43.5-45.0	18.0				90	10							SP-SM	II
	S-12	48.5-50.0	22.8				74	26		150	150				SC-SM	III
	S-13	53.5-55.0	21.5							1250	800					III

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CONSTRUCTION · REMEDIATION ·

TABLE-3: SUMMARY OF LABORATORY AND VANE SHEAR TEST RESULTS

James Island

E2CR Project No. 01572-04

Note : * Depth from the existing water surface at El. 0.00

* * See the enclosed Unified Soil Classification System

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			UNCONFINED COMPRESSION Cu (PSF)	SHEAR STRENGTH		FIELD VANE SHEAR STRENGTH			USCS CLASSIFICATION**	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)		PENETRO QP(PSF)	TORVANE TV(PSF)	UNDISTURBED (PSF)	REMOLDED (PSF)	SENSITIVITY		
JB-4	S-14	58.5-60.0	19.8					7		500	320				SC	III
	S-16	68.5-70.0	28.5					20							SC	III
JB-5	S-4	15.0-17.0	33.0													III
	S-5	17.0-19.0	25.9							250	200					III
	ST-1	19.0-21.0	47.2	47	28			53							CL	II
	S-8	28.5-30.0	30.9				74	28							SM	III
	S-9	33.5-35.0	30.6													III
	S-10	38.5-40.0	62.8							200	500					III
JB-6	S-3	15.0-17.0	33.1							250	350					II
	S-5	19.0-21.0	40.8							350	320					II
	ST-1	21.0-23.0	25.2					18							SM	III
	S-6	23.0-25.0	27.0	28	11										CL	III
	S-7	28.5-30	23.7													III
JB-7	S-3	13.0-15.0	32.9							200	320					III
	S-4	15.0-17.0	38.7							250	260					III
	S-5	17.0-19.0	25.2													III
	ST-1	21.0-22.0	39.6	33	16			40	395	350	400				SC	III
	ST-2	22.0-23.0	31.8	34	18			37	441						SC	III
	S-7	28.5-30.0	45.5							600	340					III
	S-8	33.5-35.0	24.8													III
JB-8	S-4	16.0-18.0	23.8													III
	S-5	18.0-20.0	26.0					35							SC	III
	S-6	20.0-22.0	23.2					72							CL	III
	S-9	33.5-35.0	25.9													III
	S-10	38.5-40.0	29.8													III
JB-9	S-1	9.0-11.0	31.4					21							SC	I

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TABLE-3: SUMMARY OF LABORATORY AND VANE SHEAR TEST RESULTS

James Island

E2CR Project No. 01572-04

Note : * Depth from the existing water surface at El. 0.00

** See the enclosed Unified Soil Classification System

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			UNCONFINED COMPRESSION Cu (PSF)	SHEAR STRENGTH		FIELD VANE SHEAR STRENGTH			USCS CLASSIFICATION**	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)		PENETRO OP(PSF)	TORVANE TV(PSF)	UNDISTURBED (PSF)	REMOLDED (PSF)	SENSITIVITY		
JB-9	S-2	11.0-13.0	44.3							200	200					I
	S-3	13.0-15.0	44.9													I
	S-4	15.0-17.0	48.4													I
	ST-1	19.0-21.0	45.1	40	17			98	405	650	1000				CL	III
	S-6	21.0-23.0	37.1													III
JB-9	S-7	23.0-25.0	39.6							250	200					III
	S-8	28.5-30.0	43.7					25							SC	III
	S-9	33.5-35.0	48.1													III
	S-10	38.5-35.0	38.3													III
JB-10	S-6	18.0-20.0	40.9					88		180	220				CL	II
	S-7	22.0-23.5	22.7				71	29							SC	II
	S-8	23.5-25.0	22.1				93	7							SP-SM	II
	S-9	28.5-30.0	41.7							275	200					III
	S-11	38.5-40.0	28.4					25							SC	III
	S-12	43.5-45.0	32.3					35							SC	III
	S-13	48.5-50.0	33.5				65	35							SC	III
JB-11	S-2	12.0-14.0	28.6													I
	S-3	14.0-16.0	30.0													I
	S-4	18.0-18.0	27.5							250	240					I
	S-5	18.0-20.0	29.0							250	340					I
	ST-1	22.0-24.0	32.2				58		123	100	160				CL	I
	S-7	28.5-30.0	24.2				94	6							SP-SM	II
	S-8	33.5-35.0	31.2					27							SC	II
	S-9	38.5-40.0	21.2													II
JB-12	S-3	14.0-16.0	35.9													III
	S-4	18.0-18.0	36.8							250	400					III

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TABLE-3: SUMMARY OF LABORATORY AND VANE SHEAR TEST RESULTS

James Island

E2CR Project No. 01572-04

Note : * Depth from the existing water surface at El. 0.00

* * See the enclosed Unified Soil Classification System

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			UNCONFINED COMPRESSION Cu (PSF)	SHEAR STRENGTH		FIELD VANE SHEAR STRENGTH			USCS CLASSIFICATION**	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)		PENETRO QP(PSF)	TORVANE TV(PSF)	UNDISTURBED (PSF)	REMOLDED (PSF)	SENSITIVITY		
JB-12	ST-1	18.0-20.0	37.8					74	136						CL	III
	S-5	22.0-24.0	34.2							250	280					III
	S-6	24.0-26.0	41.9													III
JB-13	S-3	9.0-11.0						17							SM	II
	ST-1	13.0-15.0	38.0	35	16			89		250	200				CL	III
	V-1	16.0-16.8	37.2									1387	427	3.2		III
	S-5	17.0-19.0	33.2													III
JB-14	S-2	10.0-12.0	36.9							235	480					II
	V-1	12.0-12.6	29.4									256	57	4.5		III
	S-3	13.0-15.0	34.5													III
	S-4	16.0-18.0	39.2													III
	S-5	18.0-20.0	41.9							172	280					III
JB-15	S-2	10.0-12.0	19.0					21							SC	II
	S-3	12.0-14.0	34.7	42	12					250	340				ML	III
	V-1	14.0-14.8	35.6									1850	598	3.1		III
	ST-1	15.0-17.0	55.3					98	750	500	540				CL	III
	V-2	17.5-18.2	34.3									1224	370	3.3		III
	S-4	18.0-20.5	23.5							250	360					III
JB-16	S-1	8.0-10.0	32.8					2							SM	II
	S-4	14.0-16.0	97.1	84	31					195	200				MH	III
	S-5	16.0-18.0	47.2													III
	S-6	18.0-20.0	22.9							1250	1180					III
	S-7	23.5-25.0	20.5							1500	1200					II
	S-8	28.5-30.0	36.8							1500	1200					III
	S-10	38.5-40.0	35.7							1500	900					III
	S-11	43.5-45.0	32.3							1415	700					III

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TABLE-3: SUMMARY OF LABORATORY AND VANE SHEAR TEST RESULTS

James Island

E2CR Project No. 01572-04

Note : * Depth from the existing water surface at EL 0.00

* * See the enclosed Unified Soil Classification System

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			UNCONFINED COMPRESSION Cu (PSF)	SHEAR STRENGTH		FIELD VANE SHEAR STRENGTH			USCS CLASSIFICATION**	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)		PENETRO OP(PSF)	TORVANE TV(PSF)	UNDISTURBED (PSF)	REMOLDED (PSF)	SENSITIVITY		
JB-17	S-1	10.0-12.0	24.4													II
	S-2	12.0-14.0	24.4													II
	S-3	14.0-16.0	25.4					17							SM	II
	S-5	18.0-20.0	30.3													III
	S-6	23.5-25.0	39.4													III
	S-7	28.5-30.0	31.8													III
	S-8	33.5-35.0	25.4													III
	S-9	38.5-40.0	24.9													III
	S-10	43.5-45.0	42.0													III
JB-18	S-1	9.0-11.0	24.2													II
	S-2	11.0-13.0	22.2													II
	S-3	13.0-15.0	28.0													II
	S-4	15.0-17.0	24.4					7							SP-SM	II
	S-5	17.0-19.0	22.2													II
	S-6	23.5-25.0	25.2	21	2										SC	II
	S-7	28.5-30.0	31.5													III
	S-8	33.5-35.0	22.0													III
	S-9	38.5-40.0	26.2													III
	S-10	43.5-45.0	29.3													III
	S-11	48.5-50.0	33.4													III
JB-19	S-1	14.5-16.0	19.9													II
	S-2	16.0-18.0	21.8													III
	S-3	18.0-20.0	21.8													II
	S-4	20.0-22.0	26.3					15							SM	II
	S-5	22.0-24.0	27.4													II
	S-6	24.0-26.0	22.8													II

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TABLE-3: SUMMARY OF LABORATORY AND VANE SHEAR TEST RESULTS

James Island

E2CR Project No. 01572-04

Note : * Depth from the existing water surface at El. 0.00

* * See the enclosed Unified Soil Classification System

SORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			UNCONFINED COMPRESSION Cu (PSF)	SHEAR STRENGTH		FIELD VANE SHEAR STRENGTH			USCS CLASSIFICATION**	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)		PENETRO QP(PSF)	TORVANE TV(PSF)	UNDISTURBED (PSF)	REMOLDED (PSF)	SENSITIVITY		
JB-19	S-7	28.5-30.0	8.8													II
	S-9	38.5-40.0	29.5													III
	ST-1	40.0-42.0	30.6	33	9			36	221	500	460				SM	III
	S-12	48..4-60.0	43.9													III
JB-20	S-1	14.0-16.0	24.1													II
	S-2	16.0-18.0	25.6													II
	S-3	18.0-20.0	28.3					5							SP-SM	II
	S-4	20.0-22.0	29.2													II
	S-6	28.5-30.0	32.3													III
	V-1	30.0-30.8										1082	626	1.7		III
	ST-1	31.0-33.0	40.7	42	24			92	390	750	620				CL	III
	V-2	33.4-34.0										1224	341	3.6		III
JB-21	S-1	9.0-11.0	54.0							166	120					II
	S-2	11.0-13.0	55.4													II
	S-3	13.0-15.0	26.7													III
	V-1	15.0-15.8										1737	939	1.8		III
	ST-1	16.0-18.0	24.1	29	12			83	441	1800	1200					III
	V-2	18.0-18.8										1110	142	7.8		III
	S-4	15.0-17.0	31.2							1000	900					III
	S-5	17.0-19.0	42.8							1000	600					III
JB-22	S-1	12.0-14.0	29.1													II
	S-2	14.0-18.0	33.9													III
	S-3	18.0-16.0	31.9													III
	S-4	16.0-20.0	30.1													III
	S-5	20.0-22.0	28.3													III
	S-6	23.5-25.0	31.8													III

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TABLE-4:
SUMMARY OF BORROW AREA SOILS DATA
James Island
E2CR Project No. 01572-04

Boring No.	Depth of Water (ft.)	Upper Clay* Thickness (ft.)	Thickness of Upper Sand (ft.)	Lower Clay* Thickness (ft.)	Thickness of Lower Sand (ft.)	Remarks
JB-1	9	0	10	31+	-	Good
JB-2	10.5	3.5	19	17+	-	Good
JB-3	10	0	13	17+	-	Good
JB-4	10.5	0	40+	-	-	Good
JB-5	9	0	7	5	17+	Good
JB-6	11	0	5	13	-	Marginal
JB-7	9	0	5	25+	-	Marginal
JB-8	9.5	0	7	13	10	Good
JB-9	8.5	0	4	17	-	No Good**
JB-10	8.5	0	18	10	12	Good
JB-11	10	13	17	-	-	No Good**
JB-12	9.5	0	4	12	2	No Good**
JB-13	5	0	7	17	-	Good
JB-14	8	0	3	10	8	No Good**
JB-15	7.5	0	5	8	13	Marginal
JB-16	8	0	5	20	17	Marginal
JB-17	10	0	8	27+	-	Good
JB-18	9	0	18	27+	-	Good
JB-19	14.5	3.5	21	11+	-	Good
JB-20	14	0	12	8	11	Good
JB-21	9	19	-	-	-	No Good**
JB-22	12	0	3	15+	-	No Good**

Note:
* Includes clay, clayey sand and sand containing too much fines, requires removal.
**Not economical to mine the sand when the strip thickness (es) exceeds 10 ft. or when the quantity of sand is less than 5 ft.

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TABLE-5: SAND BORROW AREAS AND VOLUMES

James Island

E2CR Project No. 01572-04

Section*	Color Key*	Net Area (Sq.Ft.)	Sand Depth (Ft.)	Volume (Cu.Ft.)
A		6,457,500	13	3,109,167
B		3,611,250	17	2,273,750
C		9,720,000	18	6,480,000
D		8,640,000	12	3,840,000
E		3,375,000	15	1,875,000
F		2,835,000	4	420,000
G		2,520,000	9	840,000
H		2,902,500	5	537,500
			Total Cu. Yd.	19,375,417

Reduction Factor for unknown conditions = 22%

Total Available Sand, Cubic Yard (in millions)	15.1

Reduction for loss due to Hydraulic Dredging = 15%

Net Available Sand, Cubic Yard (in millions)	12.8

Note: * See Figure 11 in Appendix A

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TABLE-6: SUMMARY OF SLOPE STABILITY ANALYSIS EXTERIOR DIKE (20FT)

James Island
E2CR Project No. 01572-04

Case	Factor of Safety		
	Circular failure		Block failure through sand
	Dike	Foundation	
Case 1A	1.49	1.50	1.59
Case 1B	1.49	1.48	1.53
Case 2	1.49	1.56	NA
Case 3	1.49	2.09	NA

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TABLE-7: SUMMARY OF SLOPE STABILITY ANALYSIS
EXTERIOR DIKE (10FT)

James Island
E2CR Project No. 01572-04

Case	Factor of Safety		
	Circular failure		Block failure through sand
	Dike	Foundation	
Case 1A	1.49	2.29	1.72
Case 1B	1.49	2.20	1.70
Case 2	1.49	2.48	N/A
Case 3	1.49	2.30	N/A

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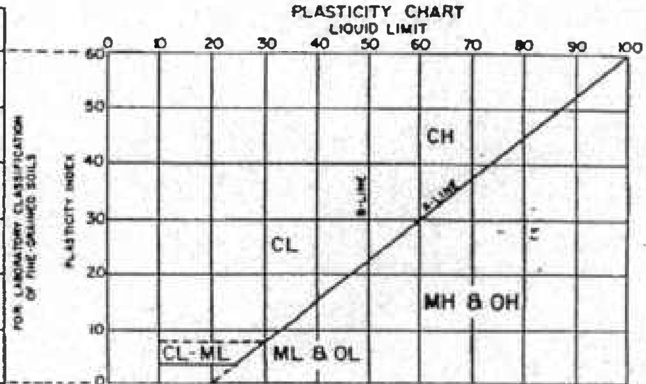
UNIFIED SOIL CLASSIFICATION SYSTEM

SOIL CLASSIFICATION CHART

MAJOR GROUPS			LETTER SYMBOL	TYPICAL DESCRIPTIONS
FINE-GRAINED SOILS 50% OR MORE PASSES No. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50%		ML	INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDS OR SILTS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY
			PT	PEAT, MUCK AND OTHER HIGHLY ORGANIC SOILS
COARSE-GRAINED SOILS MORE THAN 50% RETAINED ON No. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON No. 4 SIEVE	CLEAN GRAVELS LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES APPRECIABLE AMOUNT OF FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING No. 4 SIEVE	CLEAN SANDS LITTLE OR NO FINES	SW	WELL-GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY GRADED SANDS AND GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES APPRECIABLE AMOUNT OF FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES

PLASTICITY CHART



GRADATION CHART

MATERIAL SIZE		PARTICLE SIZE			
		LOWER LIMIT		UPPER LIMIT	
		MILLIMETERS	SIEVE SIZE	MILLIMETERS	SIEVE SIZE
SAND	FINE	.074	200	0.42	40
	MEDIUM	0.42	40	2.00	10
	COARSE	2.00	10	4.76	4
GRAVEL	FINE	4.76	4	19	3/4"
	COARSE	19	3/4"	76	3"
COBBLES		76	3"	305	12"
BOULDERS		305	12"	914	36"

Appendix C
Boring logs

E2CR, INC.

BORING LOG

PROJECT James Island			PROJECT NO. 01572-04	BORING NO. JB - 1
SITE Eastern Shore, Maryland	BEGUN 11/13/01	COMPLETED 11/13/01	HOLE SIZE	GROUND ELEVATION 0.00 at
COORDINATES N: 38° 31.740 W: 76° 19.427	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 50
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
				SAMPLE DATA					
0	0		Water						Water depth 8.8' @ 11:55 am
5	-5								
10	-10		Dark reddish gray, moist, Silty fine SAND, trace Shell (SM)	S-1	24"	1- 2- 2- 3	DS	8"	
			Medium reddish gray, Silty fine SAND, trace Shell (SM)	S-2	24"	7- 5- 5- 7	DS	18"	
				S-3	24"	12- 3- 3- 3	DS	14"	
15	-15			S-4	24"	4- 3- 2- 1	DS	14"	
				S-5	24"	WOR-1-1-1	DS	22"	
20	-20		Greenish gray, moist, Clayey SILT, little to trace fine Sand (ML)						
				S-6	18"	WOR	DS	12"	
25	-25								
				S-7	18"	WOR	DS	18"	
30	-30								
				S-8	18"	2- 1- 1	DS	18"	
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. JB - 1	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, moist, Silty CLAY, little to trace fine Sand (CL)						
				S-9	18"	2- 2- 2	DS	18"	
40	-40								
				S-10	18"	WOR/12"-1	DS	18"	
45	-45								
				S-11	18"	WOR/18"	DS	18"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT			PROJECT NO.	BORING NO.
James Island			01572-04	JB - 2
SITE: Eastern Shore, Maryland	BEGUN: 11/14/01	COMPLETED: 11/14/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 32.082 W: 76° 19.451	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 50
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 10.5'
5	-5								
10	-10								
			Greenish gray, moist, Silty CLAY, little Sand, trace shell fragments (CL)	S-1	18"	WOR/18"	DS	14"	
				S-2	24"	WOR/24"	ds	0	
15	-15		Greenish gray, moist, Silty fine SAND, trace shell fragments (SM)	S-3	24"	WOR/24"	DS	2"	
				S-4	24"	3- 2- 2- 2	DS	14"	
			Light to dark gray, moist, fine SAND, trace Silt (SP-SM)						
			Greenish gray, moist, Silty fine SAND (SM)	S-5	24"	3- 3- 1- 1	DS	20"	
20	-20			S-6	24"	1- 1- 1- 3	DS	24"	
25	-25		Gray, moist, fine to coarse SAND, trace Gravel (SM)	S-7	18"	7- 4- 5	DS	18"	
30	-30		Gray, moist, fine to coarse SAND, little fine to medium Gravel and Silt (SM)	S-8	18"	16- 27- 14	DS	18"	
35	-35		Greenish gray, moist, Silty CLAY (CH)	S-9	18"	1- 1- 2	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 2
PROJECT James Island	PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, moist, Silty CLAY (CH)						
				S-10	18"	WOR/18"	DS	14"	
40	-40								
				S-11	18"	4 - 2 - 5	DS	18"	
45	-45								
				S-12	18"	6- 7- 7	DS	18"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, Inc.	BORING LOG	BORING NO. JB - 3	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Grayish brown, Silty CLAY, trace Sand (CL)	S-9	18"	3- 4- 5	DS	18.0	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT	PROJECT NO.	BORING NO.
James Island	01572-04	JB - 3

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	11/14/01	11/14/01		0.00 at

COORDINATES	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
N: 38° 31.897 W: 76° 20.065				

DRILLER	WEIGHT OF HAMMER	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING
Tony O.	140 lbs.			40

TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY:	PAGE NO.
		C. Jacobs	1

DEPTH	STRATA ELE/ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
				SAMPLE DATA					
0	0		Water						Water depth @ 9.9'
5	-5								
10	-10		Orange brown, moist, Silty fine SAND, trace Shell fragments	S-1	24"	2- 3- 4- 4	DS	12"	
			Orange brown, moist, fine to coarse SAND, trace Shell fragments and Silt (SP-SM)	S-2	24"	6- 7- 9-10	DS	24"	
15	-15			S-3	24"	10-10-11-12	DS	24"	
			Light gray, orange brown, moist, Silty fine SAND (SM)	S-4	24"	6- 6- 5- 3	DS	24"	
				S-5	24"	5-8-15-50/3	DS	20"	
20	-20								
			Grayish brown, Silty CLAY, trace Sand (CL)	S-6	18"	4- 3- 3	DS	18"	
25	-25								
				S-7	18"	1- 4- 4	DS	18"	
30	-30								
				S-8	18"	3- 3- 5	DS	18"	
35	-35								

E2CR, INC.

BORING LOG

PROJECT James Island			PROJECT NO. 01572-04	BORING NO. JB - 4
SITE Eastern Shore, Maryland	BEGUN 11/15/01	COMPLETED 11/15/01	HOLE SIZE	GROUND ELEVATION 0.00 at
COORDINATES	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 70
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0			Water						Water Depth 11.5'
5									
10									
			Dark gray, moist, fine to medium SAND, trace shell fragments (SM)	S-1	18"	4 - 5 - 7	DS	12"	
			Bright orange brown, moist, fine to medium SAND, trace Silt (SP-SM)	S-2	24"	7-10-9-18	DS	22"	
15				S-3	24"	8-4-2-2	DS	24"	
			Light orange brown, gray, moist, Silty fine SAND, with a layer of gray Silty Clay on the top (6") (SC)	S-4	24"	WOR/12-4-5	DS	18"	
			Orange brown, gray fine SAND	S-5	24"	6-10-10-10	DS	24"	
20			Light gray, moist, fine to medium SAND (SP-SM)	S-6	24"	WOR/12- 1	DS	24"	
			Dark gray, moist, Silty fine to medium SAND, trace Shell fragments (SM)	S-7	18"	11-7-5	DS	18"	
25									
			Gray, moist, fine to medium SAND, trace fine Gravel (SM)	S-8	18"	11-7-5	DS	18"	
30			Greenish gray, moist, Silty Clay, little fine Sand (no sample)						
			Brown, moist, Silty fine SAND (SM)	S-9	18"	6-9-14	DS	18"	
35			Brown, moist, Silty fine SAND						

E2CR, INC.

BORING LOG

BORING NO. JB - 4

PROJECT: James Island

PROJECT NO. 01572-04

PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			(SM)						
			Gray, moist, fine to course SAND (SP-SM)						
40				S-10	18"	18-12-20	DS	18"	
45				S-11	18"	9-4-7	DS	18"	
50			Greenish gray, moist, Silty SAND, with a layer of 8" greenish gray Sandy Clay from 49' (SC-SM)	S-12	18"	9-4-7	DS	18"	
55			Greenish gray, moist, Silty Clay (CL)	S-13	18"	7-23-30	DS	18"	
			Greenish gray, Clayey SAND, with a 2" layer of fine to medium Sand and trace Gravel (SC-SM)						
60			Orange brown Silty CLAY (SC)	S-14	18"	6-12-26	DS	18"	
			Brownish gray fine to course SAND						
65			Greenish gray, moist, Silty SAND, with thin layers of Silty Clay and fine to coarse Sand (SM-SC)	S-15	18"	11-23-25	DS	18"	
70				S-16	18"	5-8-12	DS	18"	
			Bottom of Boring @ 70.0 feet						
75									

E2CR, INC.

BORING LOG

PROJECT James Island			PROJECT NO. 01572-04	BORING NO. JB - 5
SITE Eastern Shore, Maryland	BEGUN 11/16/01	COMPLETED 11/16/01	HOLE SIZE	GROUND ELEVATION 0.00 at
COORDINATES N: 38° 32.150 W: 76° 20.924	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 40
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.0' @ 8:40 a.m.
5	-5								
10	-10		Dark gray, moist, fine SAND, trace Silty and Shell fragments (SM)	S-1	24"	4-13-23-30	DS	18"	
			Orange brown, moist, fine SAND, trace Silt (SM)	S-7	24"	24-22-18-12	DS	22"	
			Dark gray, moist, Silty SAND, little Clay, trace Shell fragments (SM-CL)	S-3	24"	5-1-2-1	DS	20"	
15	-15			S-4	24"	5-1-2-1	DS	20"	
			Greenish gray, moist, Silty CLAY, with Sand (CL)	S-5	24"	2-1-1-2	DS	20"	
20	-20			ST-1	24"	Pushed Tube	ST	16"	
			Dark gray, fine to medium SAND, trace Gravel (SM)	S-6	24"	5-8-14-5	DS	24"	
			Green with white layers, moist, Silty fine SAND (SM)	S-7	24"	5-10-15-20	DS	24"	
25	-25								
			Grayish green, moist, Silty fine SAND, trace Clay (SM)	S-8	18"	12- 14- 21	DS	12"	
30	-30								
			Grayish green, moist, Clayey fine SAND, with white layers at	S-9	18"	8- 21- 5	DS	16"	
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. JB - 5	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			the bottom, trace Gravel (SC)						
			Grayish green, Silty CLAY (Hard, may be Bedrock) (CL)	S-10	18"	5- 11- 21	DS	18"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.				BORING LOG
PROJECT James Island			PROJECT NO. 01572-04	BORING NO. JB - 6
SITE Eastern Shore, Maryland	BEGUN 11/16/01	COMPLETED 11/16/01	HOLE SIZE	GROUND ELEVATION 0.00 at
COORDINATES N: 38° 32.314 W: 76° 20.368	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 28.7
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 11.0'
5	-5								
10	-10								
			Dark gray, moist, fine SAND, trace Silty and Shell fragments (SM)	S-1	24"	1-5-11-12	DS	19"	
			Orange brown, moist, fine SAND, trace Silt (SM)	S-2	24"	9-10-11-7	DS	18"	
15	-15			S-3	24"	WOR/24"	DS	7"	
			GReenish gray, moist, Silty CLAY (CL)						
			Brownish gray, fine to medium SAND, trace Silty (SM)	S-4	24"	11-8-4-4	DS	24"	
20	-20		Greenish gray, moist, Silty CLAY (CL)	S-5	24"	2-1-1-1	DS	24"	
			Silty SAND (SM)	ST-1	24"	Pushed Tube	ST	16"	
			Grayish brown, Clayey fine SAND, trace Gravel (SC)	S-5	24"	8-19-28-33	DS	24"	
25	-25		Green, moist, Silty CLAY with a white layer on the bottom (CL)						
			Green, moist, Silty CLAY (CL)						
			Bottom of Boring @ 28.7 feet	S-7	0.2"	50/2"	DS	0.2"	
30	-30								
35	-35								

E2CR, INC.				BORING LOG
PROJECT James Island			PROJECT NO. 01572-04	BORING NO. JB - 7
SITE Eastern Shore, Maryland	BEGUN 11/21/01	COMPLETED 11/21/01	HOLE SIZE	GROUND ELEVATION 0.00 at
COORDINATES N: 38° 32.620 W: 76° 21.890	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 40
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.0' @ 9:50 a.m.
5	-5								
10	-10		Dark gray, moist, fine to medium SAND, trace Silty, little Shell fragments (SM)	S-1	24	7-3-1-2	DS	12"	
				S-2	24"	7-10-10-7	DS	18"	
				S-3	24"	6-1-1-1	DS	18"	
15	-15		Greenish gray, moist, Silty CLAY (CL)	S-4	24"	1-1-1-2	DS	24"	
			Greenish gray, moist, Sandy CLAY (CL)	S-5	24"	2-3-2-2	DS	24"	
20	-20		Greenish gray, Clayey SAND (SC)	ST-1	24"	Pushed Tube	ST	0	
				ST-2	24"	Pushed Tube	ST	24"	
			Gray, moist, Silty fine to medium SAND (SM)	S-6	24"	19-14-14-23	DS	20"	
25	-25								
30	-30		Brownish black, moist, Silty CLAY, trace Sand (CL)	S-7	18"	1- 2- 3	DS	18"	
35	-35		Brownish black, moist, fine to medium SAND, trace Clay (SM)	S-8	18"	14- 6- 6	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 7	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Brownish black, moist, fine to medium SAND, trace Clay (SM)						
			Brownish gray, moist, fine to coarse SAND (SM)	S-9	18"	14-23-35	DS	18"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.	BORING LOG

PROJECT	PROJECT NO.	BORING NO.
James Island	01572-04	JB - 8

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	11/26/01	11/26/01		0.00 at
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 24 HRS**	**CAVED DEPTH**
N: 38° 31.115 W: 76° 21.832				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
Tony O.	140 lbs.			40
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.5" @ 10:00 a.m.
5	-5								
10	-10		Dark gray, moist, Silty fine to medium SAND, trace Shell fragments (SM)	S-1	24"	7-5-7-7	DS	12"	
				S-2	24"	6-5-5-6	DS	24"	
15	-15		Gray,moist, Silty fine SAND (SM)	S-3	24"	7-5-2-2	DS	24"	
				S-4	24"	7-2-WOR/ 12"	DS	24"	
			Greenish gray, moist, Clayey SAND (SC)	S-5	24"	WOH/24"	DS	20"	
20	-20		Greenish gray, moist, Sandy CLAY, trace Shell fragments (CL)	S-6	24"	8-14-9-14	DS	18"	
25	-25		Orange brown, moist, fine to coarse Clayey SAND, trace Silt and Gravel (SC)	S-7	18"	6-11-30	DS	18"	
30	-30		Grayish green, moist, Clayey SAND, trace Shell fragments (SC)	S-8	18"	7- 15- 30	DS	18"	
35	-35			S-9	18"	16-27-15	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 8	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Grayish green, moist, Clayey SAND, trace Shell fragments (SC)						
			Grayish green brown, moist, Clay SAND, little Gravel (CL)	S-10	18"	50/3"	DS	3"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT	PROJECT NO.	BORING NO.
James Island	01572-04	JB - 9

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	11/26/01	11/26/01		0.00 at
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 24 HRS**	**CAVED DEPTH**
N: 38° 31.200 W: 76° 21.399				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
Tony O.	140 lbs.			40
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 8.5'
5	-5								
			Light green, moist, Clayey SAND, trace Gravel (SC)	S-1	24"	6-5-5-3	DS	14"	
10	-10		Dark gray, moist, fine to medium SAND, trace Shell fragments and Silt (SM)	S-2	24"	WOH/24"	DS	24"	
			Dark gray,moist, Silty CLAY (CL)	S-3	24"	WOR/24"	DS	24"	
15	-15			S-1	24"	WOR/24"	DS	24"	
				S-5	24"	WOR/24"	DS	24"	
20	-20		Greenish gray, Silty CLAY (CL)	ST-1	24"	Pushed Tube	ST	24"	
			Greenish gray, moist, Silty CLAY (CL)						
			Grayish brown, moist, Sandy CLAY (CL)	S-7	24"	WOR/24"	DS	24"	
25	-25								
				S-8	18"	9-10-12	DS	18"	
30	-30		Light green, moist, Clayey SAND (SC)						
			Grayish brown, moist, Silty CLAY (CL)	S-9	18"	14-19-26	DS	18"	
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. JB - 9	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Light to dark green, moist, Sandy CLAY, with white layers (CL)						
			Light to dark green, moist, Sandy CLAY, with white layers (CL)	S-10	18"	21-24-26	DS	18"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT			PROJECT NO.	BORING NO.
James Island			01572-04	JB - 10
SITE: Eastern Shore, Maryland	BEGUN: 11/27/01	COMPLETED: 11/27/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 31.928 W: 76° 20.671	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 50
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 8.5'
5	-5								
			Dark gray, Moist, Silty SAND, trace Shell fragments	S-1	18"	5- 6- 6	DS	10"	
10	-10		Orange-brown tan, moist, Silty fine to medium SAND	S-2	24"	6-8-6-6	DS	14"	
				S-3	24"	11-5-4-10	DS	12"	
15	-15			S-4	24"	6-5-5-7	DS	14"	
			Gray, moist, Sandy CLAY (CL)	S-5	24"	6-2-1-1	DS	24"	
				S-6	24"	3-3-3-3	DS	24"	
20	-20		Brown to dark gray, moist, fine to coarse Silty SAND (SC)	ST-1	24"	Pushed Tube	ST	0	
			Brownish gray, poorly graded SAND, trace fines (SC)	S-7	18"	6-10-9	DS	18"	
				S-8	18"	15-16-21	DS	18"	
25	-25								
30	-30		Light green, moist, Silty CLAY, little Sand (CL)	S-9	18"	46-19-35	DS	18"	
35	-35			S-10	18"	50/3"	DS	9"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 10	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish yellow, moist, Clayey SAND, little Gravel (SC)						
			Greenish yellow, moist, Clayey SAND, little Gravel (SC)						
			Light greenish brown, moist, Clayey SAND (SC)	S-11	18"	15-22-32	DS	14"	
40	-40								
				S-12	18"	21-36-49	DS	18"	
45	-45								
				S-13	18"	18-21-30	DS	18"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT			PROJECT NO.	BORING NO.
James Island			01572-04	JB - 11
SITE: Eastern Shore, Maryland	BEGUN: 11/27/01	COMPLETED: 11/27/01	HOLE SIZE	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 30.826 W: 76° 21.068	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING: 40
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.8' @ 9:30 a.m.
5	-5								
10	-10		Greenish gray, moist, Sandy CLAY (CL)	S-1	24"	WOH/18"-2	DS	12"	
			Dark gray, moist, fine to medium SAND, trace Shell fragments and Silt (SM)	S-2	24"	3-1-1-1	DS	24"	
15	-15		Orange brown, moist, Silty CLAY, trace Sand and Gravel (CL)	S-3	24"	3-1-2-2	DS	24"	
			Gray,moist, Sandy CLAY, with a 1" layer of yellow Clayey Sand and little Gravel on the top (CL)	S-4	24"	WOH/12"-1/12"	DS	24"	
				S-5	24"	WOH/24"	DS	24"	
20	-20			ST-1	24"	Pushed Tube	ST	0	
				ST-2	12"	Pushed Tube	DS	14"	
			Grayish brown, fine to medium SAND, trace Silty and Gravel (SP-SM)	S-6	24"	WOH/24"	DS	12"	
25	-25								
				S-7	18"	12-15-19	DS	18"	
30	-30								
35	-35		Light green, moist, Clayey	S-8	18"	33.5-35.0	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 11

PROJECT James Island	PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			SAND (SC)	S-9	18"	17-28-30	DS	8"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT	PROJECT NO.	BORING NO.
James Island	01572-04	JB - 12

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	11/28/01	11/28/01		0.00 at
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 24 HRS**	**CAVED DEPTH**
N: 38° 30.334 W: 76° 21.195				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
Tony O.	140 lbs.			27.5
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.5'
5	-5								
10	-10		Dark gray,moist, Silty fine SAND, trace Shell fragments	S-1	24"	3-2-2-1	DS	10"	
			Greenish gray, moist, Silty SAND, layer of orange brown, Silty Sand @ 13.0' (SM)	S-2	24"	6-6-6-6	DS	24"	
15	-15		Light gray, moist, Silty CLAY (CL)	S-3	24"	WOR/24"	DS	6"	
				S-4	24"	2-2-2-2	DS	24"	
			Dark gray, moist, Sandy CLAY (CL-ML)	ST-1	24"	Pushed Tube	ST	7"	
20	-20			ST-2	24"	Pushed Tube	DS	24"	
				S-5	24"	2-2-2-21	DS	24"	
25	-25			S-6	24"	2-2-32-21	DS	24"	
			Dark brown, moist, Silty SAND, some Gravel						
			Bottom of Boring @ 27.5 feet						
30	-30								
35	-35								

E2CR, INC.

BORING LOG

PROJECT	PROJECT NO.	BORING NO.
James Island	01572-04	JB - 13

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	11/05/01	11/05/01		0.00 at
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 24 HRS**	**CAVED DEPTH**
N: 38° 30.267 W: 76° 20.737				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
Tony O.	140 lbs.			28.8
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 5.0' @ 9:00 a.m.
5	-5		Brownish gray,moist, fine to medium SAND, little Silty, trace Shell fragments	S-1	24"	3-2-1-4	DS	9"	
			Light brown, moist, fine SAND, little Silt (SM)	S-2	24"	4-4-4-5	DS	24"	
10	-10			S-3	24"	10-16-20-23	DS	15"	
			Greenish gray, moist, Silty CLAY (CL)	S-4	24"	10-12-5-5	DS	24"	
				ST-1	24"	Pushed Tube	ST	16"	
15	-15			VS	24"	Vane tip @ 17'	VS	26"	
			Greenish gray, moist, Sandy CLAY	S-5	24"	1-1-1-1	DS	24"	
20	-20								
			Grayish green, moist, Clayey SILT, little Sand	S-6	18"	12-17-23	DS	18"	
25	-25								
				S-7	16"	50/2"	DS	2"	
			Grayish green, moist, Silty SAND, trace Clay and Gravel						
30	-30		End of Boring after refusal 28' 8"						
35	-35								

E2CR, INC.

BORING LOG

PROJECT James Island			PROJECT NO. 01572-04	BORING NO. JB - 14
SITE Eastern Shore, Maryland	BEGUN 12/05/01	COMPLETED 12/05/01	HOLE SIZE	GROUND ELEVATION 0.00 at
COORDINATES N: 38° 29.632 W: 76° 21.054	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 28.5
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 8.0'
5	-5								
			Dark gray, moist, fine SAND, trace Silt and Shell fragments	S-1	24"	7-5-4-4	DS	24"	
10	-10		Greenish gray, moist, Clayey SAND	S-2	24"	2-1-1-1	DS	24"	
			Greenish gray, moist, Silty CLAY, trace Sand	S-3	24"	1-2-1-1	DS	24"	
15	-15		Greenish gray, moist, Silty CLAY						
				S-4	24"	WOH/24"	DS	14"	
				S-5	24"	2-1-1-1	DS	24"	
20	-20		Greenish gray, moist, fine SAND, trace Silt						
				S-6	18"	8- 12- 16	DS	18"	
25	-25								
			Auger Refusal at 28.5 feet						
30	-30								
35	-35								

E2CR, INC.

BORING LOG

PROJECT	PROJECT NO.	BORING NO.
James Island	01572-04	JB - 15

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	12/07/01	12/07/01		0.00 at
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 24 HRS**	**CAVED DEPTH**
N: 38° 29.502 W: 76° 20.418				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
Tony O.	140 lbs.			33
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 7.5' @ 9:50 a.m.
5	-5								
			Dark gray, moist, fine to medium SAND, trace Silt	S-1	24"	8-7-8-7	DS	12"	
10	-10		Orange brown, moist, fine to coarse SAND, trace Silt	S-2	24"	12-14-8-8	DS	24"	
			Orange brown, moist, fine to coarse SAND, trace Silt and Gravel (1" layer of Silty Clay at the bottom) (SC)	S-3	24"	2- 2- 2- 2	DS	24"	
			Greenish gray, moist, Silty CLAY, trace Sand (ML)	V-1	12"	14.0-14.8'	V S		
15	-15			ST-1	24"	Pushed Tube	ST	24"	
			Greenish gray, moist, Silty CLAY, trace Sand (CH)	V-2	12"	17.0-17.8'	VS		
			Greenish gray, moist, Silty CLAY, little Sand	S-4	24"	2-2-5-20	DS	24"	
20	-20		Greenish gray, moist, Silty CLAY, little Sand, (2" grayish brown Silty Sand, little Gravel at the bottom)						
			Grayish brown, moist, fine to coarse SAND, some Gravel, trace Silt	S-5	18"	50/3"	DS	3"	
25	-25								
				S-6	18"	50/3"	DS	2"	
30	-30								
			Bottom of Boring @ 33.0 feet						
35	-35								

E2CR, INC.

BORING LOG

PROJECT			PROJECT NO.	BORING NO.
James Island			01572-04	JB - 16
SITE: Eastern Shore, Maryland	BEGUN: 12/03/01	COMPLETED: 12/03/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 30.067 W: 76° 21.430	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 50
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 8.0' @ 11"45 a.m.
5	-5								
			Dark brownish gray, moist, fine Sand, trace Shell fragments and Silt (SM)	S-1	24"	WOH/12-1-2	DS	6"	
10	-10			S-2	24"	7-2-3-4	DS	14"	
			Dark gray, moist, Silt	S-3	24"	1- 1- 1- 1	DS	24"	
15	-15		Dark brown, moist, Clayey SILT (Organic) (MH)	S-4	24"	WOH/18-1	DS	24"	
				S-5	24"	1- 1- 2- 2	DS	24"	
			Gray, light green, Silty CLAY	S-6	24"	5- 6- 6- 9	DS	24"	
20	-20								
			Brownish green, moist, Silty CLAY, little fine Sand	S-7	18"	12-14-11	DS	18"	
25	-25								
				S-8	18"	9-11-16	DS	18"	
30	-30								
			Light green, moist, Silty fine	S-9	18"	15-20-45	DS	18"	
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. JB - 16
PROJECT: James Island	PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			SAND, little Clay						
			Light green, moist, Silty fine SAND, little Clay	S-10	18"	12-12-18	DS	18"	
40	-40		Light green, moist, Silty SAND, little Clay with white thin lines	S-11	18"	16-34-37	DS	18"	
45	-45			S-12	18"	14-21-30	D	18"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.				BORING LOG
PROJECT: James Island			PROJECT NO.: 01572-04	BORING NO.: JB - 17
SITE: Eastern Shore, Maryland	BEGUN: 12/10/01	COMPLETED: 12/10/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 32.009 W: 76° 21.339	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 44.5
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 10. 0' @ 1:00 p.m.
5	-5								
10	-10		Dark gray fine to medium SAND, trace Silt and Shell fragments	S-1	24"	5- 4- 6- 6	DS	16"	
			Orange brown, moist, fine to medium SAND, little Silt	S-2	24"	6- 5- 4- 3	DS	12"	
15	-15		Gray, moist, Silty fine SAND (SM)	S-3	24"	4- 2- 2- 2	DS	24"	
				S-4	24"	4- 2- 2- 2	DS	24"	
			Gray, moist, Silty CLAY, little Sand	S-5	24"	1- 1- 1- 1	DS	24"	
20	-20								
			Greenish gray, moist, Silty CLAY, little Sand (6" layer if Sand, and Gravel @ 24', with thin white layers)	S-6	18"	10- 3- 4	DS	18"	
25	-25								
				S-7	18"	10- 20- 22	DS	18"	
30	-30								
				S-8	18"	10- 20- 37	DS	18"	
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. JB - 17
PROJECT James Island	PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, moist, Silty CLAY, little Sand (6" layer if Sand, and Gravel @ 24', with thin white layers)						
				S-9	18"	16- 34- 46	DS	15"	
40	-40								
			Grayish green, moist, Silty CLAY, little Sand with thin white layers	S-10	12"	48-50/2"	DS	8"	
45	-45								
			Bottom of Boring @ 44.5 feet						
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT			PROJECT NO.	BORING NO.
James Island			01572-04	JB - 18
SITE: Eastern Shore, Maryland	BEGUN: 12/06/01	COMPLETED: 12/06/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 32.240 W: 76° 20.358	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 56
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.0'
5	-5								
10	-10		Dark gray, moist, fine to medium SAND, trace Silt and Shell fragments	S-4	24"	4- 4- 7- 9	DS	18"	
			Tan, moist, fine to medium SAND, trace Silt	S-2	24"	12-15-10-9	DS	6"	
			Orange brown, tan, moist, fine to medium SAND, little Silt, trace Shell and Organics	S-3	24"	1-2-1-4	DS	24"	
15	-15		Orange brown, moist, fine to medium SAND, trace Silt (SP-SM)	S-4	24"	12-14-15-21	DS	14"	
				S-5	24"	17-14-11-11	DS	24"	
20	-20		Orange brown, moist, Clayey SAND, some Shell fragments (SC)						
25	-25		Gray, moist, Clayey SAND, some Shell fragments (SC)	S-6	18"	3- 5- 5	DS	18"	
			Greenish gray, moist, Silty CLAY, little Sand						
30	-30			S-7	18"	5- 6- 14	DS	18"	
35	-35			S-8	18"	5- 15- 31	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 18	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, moist, Silty CLAY, little Sand						
				S-9	18"	12- 15- 24	DS	18"	
40	-40								
				S-10	18"	9- 23- 52	DS	18"	
45	-45								
				S-11	18"	7- 11- 105	DS	18"	
50	-50								
				S-12	18"	33-50/2"	DS	18"	
55	-55		Greenish gray, moist, Sandy SILT, trace fine Gravel						
			Bottom of Boring @ 56.0 feet						
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.				BORING LOG
PROJECT: James Island			PROJECT NO.: 01572-04	BORING NO.: JB - 19
SITE: Eastern Shore, Maryland	BEGUN: 12/06/01	COMPLETED: 12/06/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 32.561 W: 76° 20.086	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 50
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 14. 5 @ 9:00 a.m.
5	-5								
10	-10								
15	-15		Dark gray, moist, Silty fine to medium SAND, with a layer of orange brown, Silty fine to medium Sand at the bottom	S-1	18"	5- 8- 9	DS	18"	
				S-2	24"	5- 6- 6- 7	DS	24"	
			Greenish gray, moist, Silty CLAY, with a layer of (8") orange brown, moist, Silty fine to medium Sand	S-3	24"	8- 8- 8- 8	DS	24"	
20	-20			S-4	24"	6- 7- 9-12	DS	24"	
			Greenish gray and orange brown, Silty fine to medium SAND (SM)	S-5		16-8-32-44	DS	24"	
25	-25		Orange brown to light brown, moist, Silty fine to medium SAND (SM)	S-6	24"	4-5-11-22	DS	24"	
			Orange brown, moist, Silty fine to medium SAND						
			Light brown, moist, fine to medium SAND, trace Silt						
30	-30			S-7	18"	54-53-50/3	DS	18"	
			Light brown, moist, fine to coarse SAND, some Gravel						
35	-35		Gray, moist, Clayey SAND	S-8	18"	16-3-2	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 19	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Gray, moist, Clayey SAND						
			Greenish gray, moist, Clayey SILT, little Sand (ML)	S-9	18"	9- 4- 4	DS	18"	
40	-40			ST-1	24.0	Pushed Tube		18"	
				S-10	18"	9- 19-35	DS	18"	
			Gray, moist, fine to coarse SAND	S-11	18"	4- 4- 4	DS	18"	
45	-45		Greenish gray, moist, Clayey fine to coarse SAND						
			Greenish gray, moist, Silty CLAY	S-12	18"	5- 6- 11	DS	18"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT: James Island			PROJECT NO.: 01572-04	BORING NO.: JB - 20
SITE: Eastern Shore, Maryland	BEGUN: 12/12/01	COMPLETED: 12/12/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 32.640 W: 76° 20.849	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 45
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 14. 0' 9:30 a.m.
5	-5								
10	-10								
15	-15		Brownish gray, moist, Silty SAND, with a 6" layer of Silty Clay, trace Shell fragments on the top	S-1	24"	WOR/16/2/ 3/3	DS	18"	
			Orange brown, moist, Silty fine SAND, with a layer gray fine Sand, trace Shell fragments and Silt (SP-SM)	S-2	24"	2-4-5-6	DS	24"	
				S-3	24"	12-14-15- 20	DS	20"	
20	-20			S-4	24"	11-14-8-8	DS	24"	
				S-5	24"	14-10-12-8	DS	24"	
25	-25								
			Greenish gray, moist, Silty CLAY (CL)						
				S-6	18"	1- 2- 2	DS	18"	
30	-30			V-1	12"	Vane Shear	VS		
				ST-1	24"	Pushed Tube	ST		
				V-2	12"	Vane Shear	VS		
35	-35		Dark gray, moist, Silty SAND,	S-7	18"	9- 6- 5	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. JB - 20	
PROJECT James Island		PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE/ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			trace Clay and Shell fragments						
			Dark gray, moist, Silty SAND, trace Clay and Shell fragments						
				S-8	18"	6- 9- 12	DS	18"	
40	-40								
				S-9	18"	50/5"	DS	5"	
45	-45		Bottom of Boring @ 45.0 feet						
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT				PROJECT NO.	BORING NO.
James Island				01572-04	JB - 21
SITE: Eastern Shore, Maryland	BEGUN: 12/10/01	COMPLETED: 12/10/01	HOLE SIZE:		GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 31.619 W: 76° 20.712	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:		CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:		DEPTH OF BORING: 28
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs			PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.0' @ 9:30 a.m.
5	-5								
10	-10		Dark gray, moist, Silty CLAY	S-1	24"	WOR/24"	DS	24"	
				S-2	24"	WOR/24"	DS	24"	
			Grayish green, moist, Silty CLAY, little Sand	S-3	24"	5- 7- 7- 8	DS	24"	
15	-15		Greenish gray, Silty CLAY (CL)	V-1	12"	Vane Shear	VS		
				ST-1	24"	Pushed Tube	ST	24"	
				V-2	12"	Vane Shear	VS		
20	-20			S-4	24"	5-4-3-4	DS		
			Grayish green, moist, Silty CLAY, little Sand						
				S-5	18"	6- 3- 4	DS	18"	
25	-25								
			Bottom of Boring @ 28.0 feet						
30	-30								
35	-35								

E2CR, INC.

BORING LOG

PROJECT: James Island			PROJECT NO.: 01572-04	BORING NO.: JB - 22
SITE: Eastern Shore, Maryland	BEGUN: 12/10/01	COMPLETED: 12/10/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at
COORDINATES: N: 38° 32.110 W: 76° 21.825	DEPTH WATER ENC.:	AT END DRILL:	AT 24 HRS:	CAVED DEPTH:
DRILLER: Tony O.	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 28
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 12. 0' @ 9:10 a.m.
5	-5								
10	-10								
			Dark gray, moist, fine to medium SAND, trace Silty and Shell fragments	S-1	24"	23-10-3-3	DS	24"	
15	-15		Greenish gray, moist, Silty CLAY, trace Sand	S-2	24"	1- 1- 1- 1	DS	24"	
				S-3	24"	2- 1- 1- 1	DS	24"	
				S-4	24"	1- 1- 1- 5	DS	24"	
20	-20		Green gray, moist, Silty CLAY, with a 6" layer of fine to coarse SAND, little Gravel 21. 5'	S-5	24"	26- 15- 9	DS	24"	
			Grayish green, moist, Silty CLAY, little Sand	S-6	18"	26- 30- 35	DS	18"	
25	-25								
			Bottom of Boring @ 28.0 feet						
30	-30								
35	-35								

E2CR, INC. — BORING LOG

PROJECT	PROJECT NO.	BORING NO.
James Island	01572-04	CP - 1

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	11/29/01	11/29/01		0.00 at

COORDINATES	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
N: 38° 32. W: 76° 19.841				

DRILLER	WEIGHT OF HAMMER	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING
Tony O.	140 lbs.			50

TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY:	PAGE NO.
		C. Jacobs	1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water Depth @ 12.0'
5	-5								
10	-10								
			Gray Silty SAND Boring						
15	-15								
20	-20		CPT						
			Greenish gray, Silty SAND Boring						
25	-25								
30	-30								
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. CP - 1
PROJECT: James Island	PROJECT NO. 01572-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, Silty SAND Boring						
40	-40		CPT						
45	-45								
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.				BORING LOG	
PROJECT James Island				PROJECT NO. 01572-04	BORING NO. CP - 2
SITE Eastern Shore, Maryland	BEGUN 12/04/01	COMPLETED 12/04/01	HOLE SIZE		GROUND ELEVATION 0.00 at
COORDINATES N: 38° 31.696 W: 76° 21.463	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS		CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE		DEPTH OF BORING 27
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs			PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 10. 0 @ 8:45 a.m.
5	-5								
10	-10		Gray, moist, Sandy CLAY Boring						
				S-1	18"	WOR/24"			
15	-15		CPT						
20	-20		Gray, Sandy CLAY Boring						
25	-25								
			Bottom of boring @ 27.0 feet						
30	-30								
35	-35								

E2CR, INC.

BORING LOG

PROJECT		PROJECT NO.	BORING NO.
James Island		01572-04	CP - 3

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	12/04/01	12/04/01		0.00 at
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 24 HRS**	**CAVED DEPTH**
N: 38° 29.995 W: 76° 20.874				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
Tony O.	140 lbs.			25
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 7.0' @ 2:00 p.m.
5	-5								
10	-10		Boring						
				S-1	18"	2- 1- 1	DS	18"	
15	-15								
			CPT						
20	-20								
			Greenish gray, Sandy CLAY						
			Boring						
25	-25		Bottom of Boring @ 25.0 feet						
30	-30								
35	-35								

E2CR, INC.				BORING LOG
PROJECT James Island			PROJECT NO. 01572-04	BORING NO. CP - 4
SITE Eastern Shore, Maryland	BEGUN 12/04/01	COMPLETED 12/04/01	HOLE SIZE	GROUND ELEVATION 0.00 at
COORDINATES N: 38° 30.516 W: 76° 21.723	DEPTH WATER ENC.	AT END DRILL	AT 24 HRS	CAVED DEPTH
DRILLER Tony O.	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 37
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 8.0' @ 11:15 a.m.
5	-5								
10	-10		Greenish gray, moist, Silty CLAY Boring						
				S-1	24"	2- 2- 1- 2	DS	24"	
15	-15		CPT						
20	-20		Dark green, moist, Clayey SAND, little fine to medium Gravel						
25	-25								
30	-30								
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. CP - 4

PROJECT	PROJECT NO.	PAGE
James Island	01572-04	2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Boring	S-2	24"	50/2"	DS	2"	
			Bottom of Boring @ 37.0 feet						
40	-40								
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

Appendix D
CPT Data

ENGINEERING · CONSULTATION ·
E2CR inc.
CONSTRUCTION · REMEDIATION ·

LEGEND FOR CPT TEST DATA RESULTS

James Island
E2CR Project No. 01572-04

? = Soil Classification based on tip resistance and sleeve friction is undefined. That is, the shear behavior is some where between that for a sand and clay.

1 E 2 C R
0

Operator :AL MYERS
On Site Loc:CPT - 01
Job No. :JAMES ISLAND
Tot. Unit Wt. (avg) : 115 pcf

CPT Date :11-29-01 11:16
Cone Used :416
Water table (feet) : 0

DEPTH (meters)	(feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
6.46	21	8.93	0.01	0.10	0.28	sensitive fine grained	UNDFND	UNDFD	4	.5
6.76	22	35.00	0.01	0.03	0.57	sand to silty sand	40-50	38-40	8	UNDEFINED
7.11	23	42.13	0.01	0.02	0.60	sand to silty sand	40-50	38-40	10	UNDEFINED

Dr - All sands (Jamiolkowski et al. 1985) PHI - Robertson and Campanella 1983 Su: Nk= 16

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.04) ****

SOUNDING DATA IN FILE JI0001 11-29-01 11:16

OPERATOR : AL MYERS LOCATION : CPT - 01

CONE ID : 416 JOB No. : JAMES ISLAND

E 2 C R

DEPTH meters	DEPTH feet	TIP Qc tsf	FRICTION Fs tsf	FR RATIO Fs/Qc %	PORE PR Pw psi	P P RATIO Pw/Qc %	DIFF P P RATIO (Pw-Ph)/Qc %	INC I deg	INTERPRETED SOIL TYPE	N SPT
6.20	20.3	6	0.01	0.19	3.6	4.58	-6.57	6.5	?	?
6.25	20.5	27	0.00	0.00	3.3	0.87	-1.49	1.4	sandy silt to clayey silt	5
6.30	20.7	5	0.00	0.07	3.5	4.65	-7.12	11.7	sandy silt to clayey silt	5
6.35	20.8	5	0.01	0.13	3.5	5.49	-8.68	2.3	sensitive fine grained	3
6.40	21.0	6	0.03	0.51	3.6	4.50	-7.01	10.3	sensitive fine grained	2
6.45	21.2	5	0.00	0.04	3.4	4.82	-8.35	0.1	silty sand to sandy silt	5
6.50	21.3	38	0.02	0.05	2.3	0.43	-1.32	0.6	silty sand to sandy silt	10
6.55	21.5	50	0.03	0.06	1.6	0.23	-1.12	0.2	sand to silty sand	10
6.60	21.7	40	0.00	0.01	3.4	0.62	-1.07	0.1	sand to silty sand	10
6.65	21.8	32	0.00	0.01	5.1	1.14	-0.98	0.1	silty sand to sandy silt	10
6.70	22.0	17	0.00	0.00	4.1	1.72	-2.27	0.1	silty sand to sandy silt	9
6.75	22.1	33	0.00	0.01	4.0	0.88	-1.24	0.1	silty sand to sandy silt	9
6.80	22.3	35	0.02	0.06	4.4	0.91	-1.11	0.1	sand to silty sand	8
6.85	22.5	33	0.02	0.06	4.1	0.91	-1.25	0.1	sand to silty sand	9
6.90	22.6	46	0.00	0.01	4.1	0.64	-0.90	0.1	sand to silty sand	10
6.95	22.8	53	0.00	0.01	4.5	0.62	-0.74	0.1	sand to silty sand	13
7.00	23.0	61	0.01	0.01	4.4	0.52	-0.66	0.1	sand to silty sand	11
7.05	23.1	25	0.00	0.02	4.0	1.16	-1.75	0.1	sand to silty sand	10
7.10	23.3	44	0.00	0.01	3.6	0.59	-1.06	0.1	sand to silty sand	8
7.15	23.5	32	0.00	0.01	4.0	0.92	-1.39	0.1	?	?
7.20	23.6	49	?	?	4.1	0.59	-0.90	0.1	?	?
7.25	23.8	95	?	?	4.4	0.33	-0.45	0.1	?	?

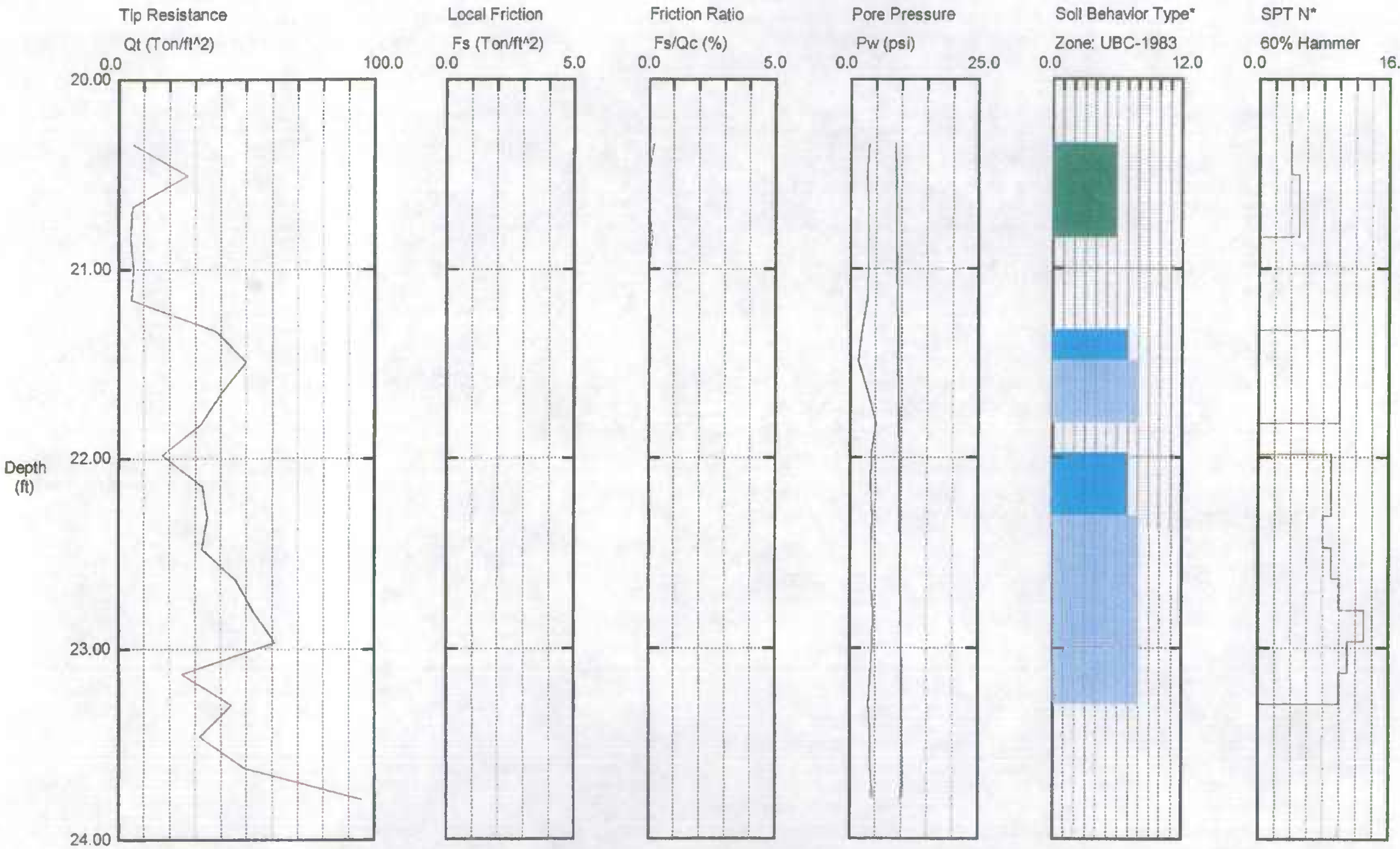
Soil interpretation reference: Robertson & Campanella-1983, based on 60% hammer efficiency and .15 m sliding data average

*Soil behavior type and SPT based on data from UBC-1983

E2CR

Operator: AL MYERS
Sounding: JI0001
Cone Used: 416

CPT Date/Time: 11-29-01 11:16
Location: CPT - 01
Job Number: JAMES ISLAND



Maximum Depth = 23.79 feet

Depth Increment = 0.16 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

1 E 2 C R

0

Operator :AL MYERS

On Site Loc:CPT - 01A

Job No. :JAMES ISLAND

Tot. Unit Wt. (avg) : 115 pcf

CPT Date :11-29-01 13:16

Cone Used :416

Water table (feet) : 0

DEPTH (meters)	(feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
12.50	41	1.20	0.18	14.81	0.54	undefined	UNDFND	UNDFD	UDF	UNDEFINED
12.80	42	3.03	0.07	2.42	1.09	clay	UNDFND	UNDFD	3	.1
13.15	43	3.41	0.18	5.21	1.12	clay	UNDFND	UNDFD	3	.1
13.45	44	3.40	0.18	5.24	1.15	clay	UNDFND	UNDFD	3	.1
13.75	45	4.28	0.17	3.90	1.17	clay	UNDFND	UNDFD	4	.1
14.05	46	4.35	0.17	3.84	1.20	clay	UNDFND	UNDFD	4	.1
14.35	47	4.80	0.23	4.81	1.22	clay	UNDFND	UNDFD	5	.1
14.65	48	4.30	0.20	4.72	1.25	clay	UNDFND	UNDFD	4	.1
14.95	49	4.67	0.15	3.13	1.28	clay	UNDFND	UNDFD	4	.1
15.25	50	7.37	-5461.17	-74133.47	1.30	undefined	UNDFND	UNDFD	UDF	UNDEFINED

Dr - All sands (Jamiolkowski et al. 1985) PHI - Robertson and Campanella 1983 Su: Nk= 16

**** Note: for interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.04) ****

SOUNDING DATA IN FILE JI0002 11-29-01 13:16

OPERATOR : AL MYERS LOCATION : CPT - 01A

CONE ID : 416 JOB No. : JAMES ISLAND

E 2 C R

DEPTH meters	DEPTH feet	TIP Qc tsf	FRICTION Fs tsf	FR RATIO Fs/Qc %	PORE PR Pw psi	P P RATIO Pw/Qc %	DIFF P P RATIO (Pw-Ph)/Qc %	INC I deg	INTERPRETED SOIL TYPE	N SPT
12.25	40.2	1	0.36	35.29	1.0	7.04	%-115.99	0.3	?	?
12.30	40.4	4	0.26	7.03	5.4	10.50	-23.58	0.1	?	?
12.35	40.5	0	0.13	150.50	7.0	594.70	%-893.66	0.5	?	?
12.40	40.7	0	0.12	136.50	23.0	?	453.48	0.6	?	?
12.45	40.8	1	0.09	6.48	38.6	198.39	107.46	0.3	?	?
12.50	41.0	1	0.11	12.43	48.0	387.11	243.64	0.3	organic material	1
12.55	41.2	2	0.06	2.84	59.0	203.90	142.16	0.3	clay	2
12.60	41.3	5	0.06	1.22	54.9	86.12	58.00	0.3	sensitive fine grained	2
12.65	41.5	4	0.08	1.86	55.1	94.27	63.47	0.3	clay	3
12.70	41.7	2	0.09	5.50	58.4	260.47	179.92	0.3	clay	3
12.75	41.8	3	0.08	2.92	70.0	179.79	133.23	0.3	clay	2
12.80	42.0	3	0.08	2.63	70.6	175.93	130.56	0.3	clay	3
12.85	42.2	4	0.23	5.64	76.0	134.10	101.83	0.3	clay	3
12.90	42.3	3	0.22	6.59	77.1	163.24	124.38	0.3	clay	4
12.95	42.5	4	0.17	3.87	53.0	88.89	57.98	0.4	clay	4
13.00	42.7	4	0.17	4.47	68.5	130.43	95.22	0.4	clay	3
13.05	42.8	3	0.15	5.24	78.1	200.58	152.93	0.4	clay	3
13.10	43.0	3	0.16	4.56	78.5	166.26	126.79	0.4	clay	3
13.15	43.1	2	0.16	7.45	79.3	274.26	209.57	0.4	clay	3
13.20	43.3	3	0.18	5.80	79.0	188.50	143.69	0.5	organic material	2
13.25	43.5	3	0.17	6.14	82.8	219.30	169.40	0.5	clay	3
13.30	43.6	4	0.18	4.84	83.4	162.43	125.58	0.5	clay	3
13.35	43.8	3	0.18	6.16	86.0	214.41	167.09	0.5	clay	3
13.40	44.0	4	0.19	4.46	87.1	146.06	114.08	0.5	clay	3
13.45	44.1	4	0.18	4.73	89.9	171.10	134.67	0.5	clay	4
13.50	44.3	5	0.18	3.69	92.2	138.24	109.44	0.5	clay	4
13.55	44.5	4	0.18	4.31	92.9	155.79	123.45	0.5	clay	4
13.60	44.6	4	0.17	3.91	91.5	149.01	117.49	0.6	clay	4
13.65	44.8	4	0.18	4.34	90.6	159.92	125.64	0.6	clay	4
13.70	44.9	4	0.18	4.53	92.9	171.14	135.25	0.6	clay	4
13.75	45.1	4	0.11	2.69	88.5	151.41	117.94	0.6	clay	4
13.80	45.3	4	0.17	3.76	89.9	146.49	114.50	0.6	clay	3
13.85	45.4	2	0.19	8.11	77.6	243.63	181.81	0.7	clay	4
13.90	45.6	5	0.15	3.28	83.5	133.45	101.84	0.8	clay	4
13.95	45.8	5	0.17	3.37	91.6	131.50	103.01	0.8	clay	4
14.00	45.9	4	0.17	3.98	93.1	156.23	122.82	0.8	clay	5
14.05	46.1	6	0.16	2.87	98.9	126.96	101.30	0.8	clay	5
14.10	46.3	5	0.18	4.00	94.8	151.63	119.57	0.8	clay	5
14.15	46.4	5	0.28	5.81	68.1	102.18	71.99	0.8	clay	5
14.20	46.6	6	0.29	5.02	79.9	101.01	75.47	0.8	clay	5

Soil interpretation reference: Robertson & Campanella-1983, based on 60% hammer efficiency and .15 m sliding data average

DEPTH meters	DEPTH feet	TIP Qc tsf	FRICTION Fs tsf	FR RATIO Fs/Qc %	PORE PR Pw psi	P P RATIO Pw/Qc %	DIFF P P RATIO (Pw-Ph)/Qc %	INC I deg	INTERPRETED SOIL TYPE	N SPT
14.25	46.8	6	0.24	4.13	86.3	105.26	80.55	0.9	clay	5
14.30	46.9	4	0.21	5.09	91.2	156.11	121.30	0.9	clay	4
14.35	47.1	4	0.18	4.90	93.1	181.29	141.54	0.9	clay	4
14.40	47.2	4	0.20	4.87	88.5	151.41	116.35	0.9	clay	4
14.45	47.4	3	0.17	5.51	89.4	207.42	159.71	0.9	clay	4
14.50	47.6	4	0.20	4.80	91.1	155.87	120.57	0.9	clay	3
14.55	47.7	2	0.20	8.20	95.1	287.81	225.18	0.9	clay	4
14.60	47.9	6	0.22	3.50	106.2	123.26	99.16	0.9	clay	5
14.65	48.1	6	0.23	4.02	110.1	139.29	112.94	0.9	clay	6
14.70	48.2	7	0.11	1.59	109.9	114.98	93.11	0.9	silty clay to clay	4
14.75	48.4	7	0.11	1.56	106.0	108.88	87.33	0.9	silty clay to clay	4
14.80	48.6	4	0.09	2.48	128.2	244.16	204.07	1.1	clay	5
14.85	48.7	4	0.13	3.46	128.8	245.28	205.06	1.1	clay	3
14.90	48.9	3	0.20	6.95	133.4	342.61	288.20	1.1	clay	3
14.95	49.0	4	0.24	6.46	134.8	262.49	221.07	1.1	clay	4
15.00	49.2	7	0.18	2.78	131.5	143.71	120.38	1.1	clay	6
15.05	49.4	9	0.17	1.82	129.9	99.57	83.16	1.1	silty clay to clay	5
15.10	49.5	7	0.22	3.15	127.8	131.30	109.24	1.1	silty clay to clay	5
15.15	49.7	6	0.21	3.66	131.7	166.59	139.34	1.1	clay	7
15.20	49.9	8	0.22	2.81	131.5	119.81	100.11	1.2	?	?
15.25	50.0	8	?	?	128.7	121.88	101.34	1.2	?	?
15.30	50.2	78	?	?	138.0	12.68	10.68	1.2	?	?

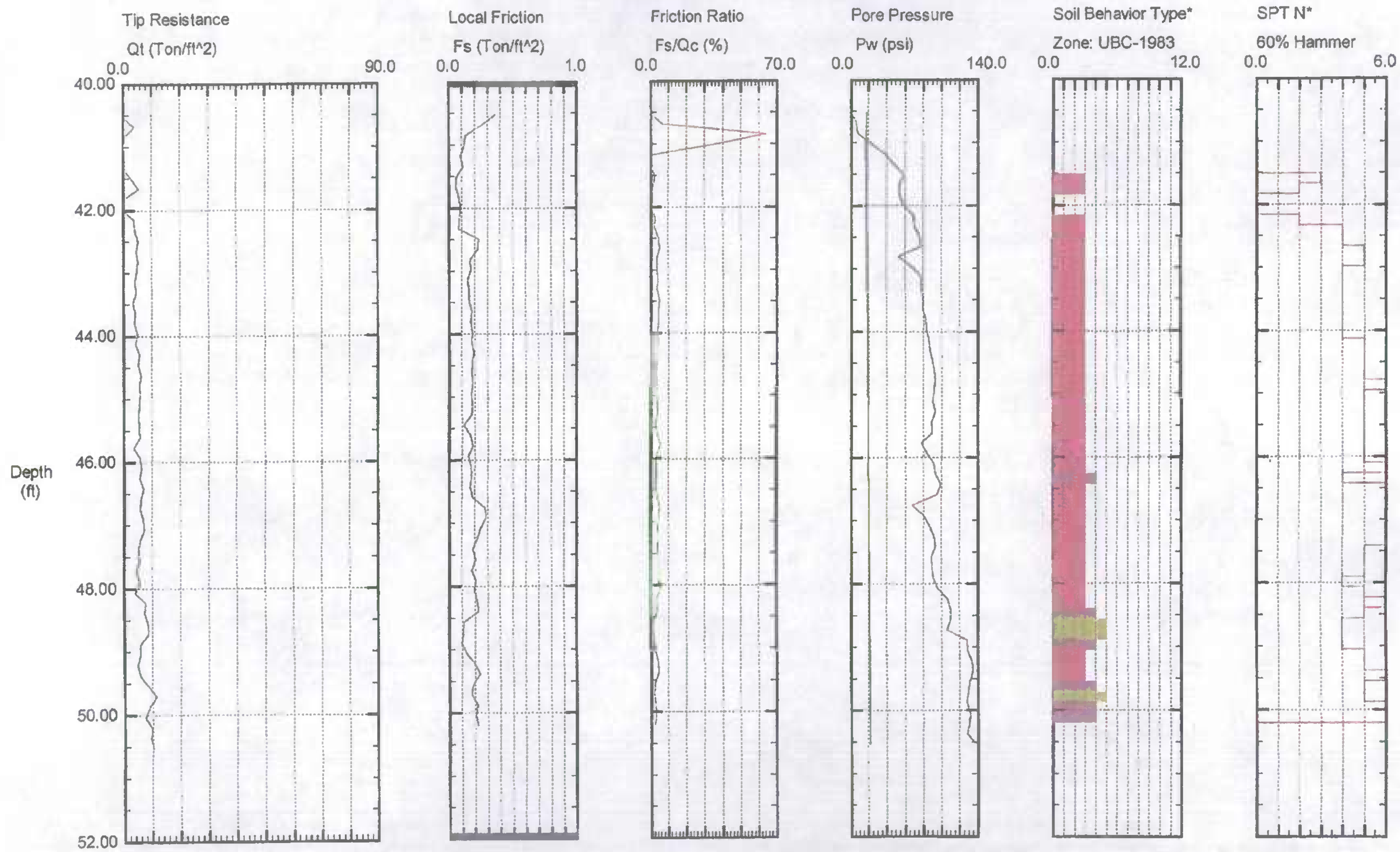
Soil interpretation reference: Robertson & Campanella-1983, based on 60% hammer efficiency and .15 m sliding data average

*Soil behavior type and SPT based on data from UBC-1983

E2CR

Operator: AL MYERS
Sounding: JI0002
Cone Used: 416

CPT Date/Time: 11-29-01 13:16
Location: CPT - 01A
Job Number: JAMES ISLAND



Maximum Depth = 50.52 feet

Depth Increment = 0.16 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

1 E 2 C R

0

Operator :AL MYERS

On Site Loc:CPT - D2

Job No. :JAMES ISLAND

Tot. Unit Wt. (avg) : 115 pcf

CPT Date :12-D4-D1 D9:25

Cone Used :416

Water table (feet) : D

DEPTH (meters)	(feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
4.87	16	3.25	0.09	2.80	0.21	clay	UNDFND	UNDFD	3	.1
5.17	17	2.58	0.D8	2.94	D.43	clay	UNDFND	UNDFD	2	.1
5.52	18	2.54	0.08	3.32	0.46	clay	UNDFND	UNDFD	2	.1
5.82	19	3.05	0.09	2.81	0.49	clay	UNDFND	UNDFD	3	.1

Dr - All sands (Jamiolkowski et al. 1985) PHI - Robertson and Campanella 1983 Su: Nk= 16

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.D4) ****

SOUNDING DATA IN FILE JI0004 12-04-01 09:25

OPERATOR : AL MYERS LOCATION : CPT - 02

CONE ID : 416 JOB No. : JAMES ISLAND

E 2 C R

DEPTH meters	DEPTH feet	TIP Qc tsf	FRICTION Fs tsf	FR RATIO Fs/Qc %	PORE PR Pw psi	P P RATIO Pw/Qc %	DIFF P P RATIO (Pw-Ph)/Qc %	INC I deg	INTERPRETED SOIL TYPE	N SPT
4.60	15.1	2	0.10	5.21	19.1	68.80	45.21	0.1	?	?
4.65	15.3	2	0.09	3.96	20.2	63.40	42.64	0.1	clay	2
4.70	15.4	3	0.09	3.75	20.9	59.89	40.69	0.1	clay	3
4.75	15.6	4	0.09	2.40	14.2	26.23	13.79	0.1	clay	3
4.80	15.7	4	0.10	2.28	15.1	25.77	14.08	0.1	clay	4
4.85	15.9	5	0.07	1.46	14.5	22.70	11.87	0.1	sensitive fine grained	2
4.90	16.1	5	0.07	1.58	13.2	21.08	9.93	0.1	sensitive fine grained	2
4.95	16.2	2	0.07	3.27	14.1	48.90	24.55	0.1	clay	3
5.00	16.4	2	0.07	3.21	15.4	50.12	26.95	0.1	clay	2
5.05	16.6	2	0.08	4.11	16.4	59.05	33.15	0.1	clay	2
5.10	16.7	2	0.08	3.80	17.4	60.30	35.21	0.1	clay	2
5.15	16.9	3	0.08	3.28	18.2	50.70	30.35	0.1	clay	2
5.20	17.1	3	0.08	3.19	19.1	54.87	33.63	0.1	clay	2
5.25	17.2	3	0.08	3.16	19.9	55.22	34.47	0.1	clay	2
5.30	17.4	2	0.09	3.94	21.1	68.75	44.19	0.1	clay	2
5.35	17.6	3	0.08	3.31	22.5	64.51	42.65	0.1	clay	2
5.40	17.7	3	0.09	3.39	23.4	64.88	43.54	0.1	clay	2
5.45	17.9	2	0.09	3.70	24.1	72.89	49.43	0.1	clay	3
5.50	18.0	3	0.08	2.75	24.4	58.12	39.45	0.1	clay	3
5.55	18.2	3	0.08	2.92	24.8	63.62	43.35	0.1	clay	3
5.60	18.4	3	0.09	3.43	25.2	70.14	48.01	0.1	clay	3
5.65	18.5	3	0.08	3.07	25.7	73.86	50.78	0.1	clay	2
5.70	18.7	2	0.09	3.95	26.2	79.29	54.76	0.1	clay	3
5.75	18.9	4	0.09	2.10	26.5	46.72	32.28	0.1	clay	3
5.80	19.0	4	0.09	2.20	26.7	49.20	34.01	0.1	clay	4
5.85	19.2	4	0.14	3.65	28.1	53.53	37.69	0.1	?	?
5.90	19.4	4	?	?	29.7	54.75	39.29	0.1	?	?
5.95	19.5	91	?	?	32.3	2.56	1.89	0.1	?	?

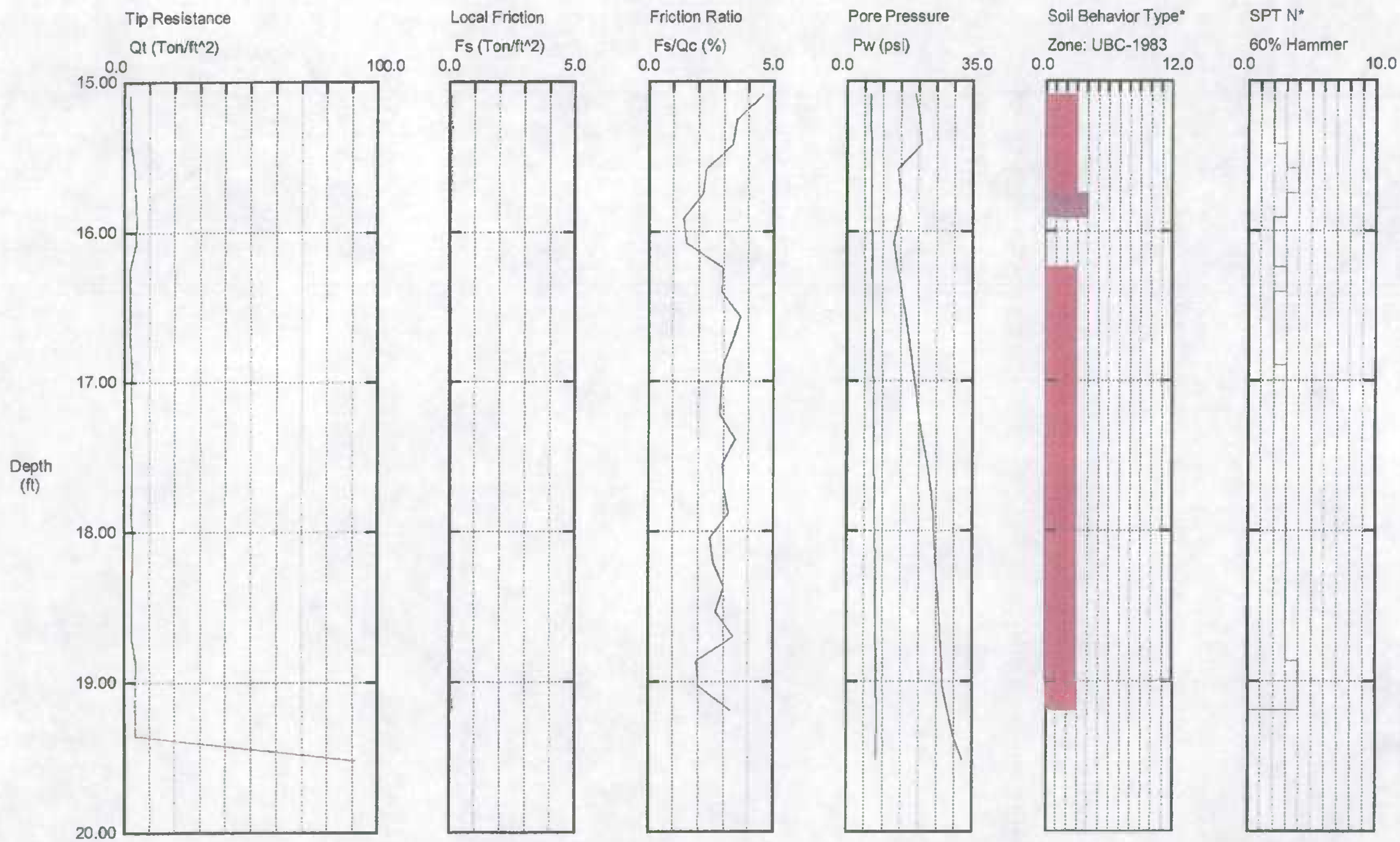
Soil interpretation reference: Robertson & Campanella-1983, based on 60% hammer efficiency and .15 m sliding data average

*Soil behavior type and SPT based on data from UBC-1983

E2CR

Operator: AL MYERS
Sounding: JI0004
Cone Used: 416

CPT Date/Time: 12-04-01 09:25
Location: CPT - 02
Job Number: JAMES ISLAND



Maximum Depth = 19.52 feet

Depth Increment = 0.16 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

1 E 2 C R
0

Operator :AL MYERS
On Site Loc:CPT - 03
Job No. :JAMES ISLAND
Tot. Unit Wt. (avg) : 115 pcf

CPT Date :12-04-01 14:18
Cone Used :416
Water table (feet) : 0

OEPTH (meters)	(feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
4.87	16	4.92	0.02	0.45	0.21	sensitive fine grained	UNDFND	UNDFD	2	.2
5.17	17	5.60	0.02	0.39	0.43	sensitive fine grained	UNOFNO	UNOFD	3	.2
5.52	18	6.14	0.03	0.44	0.46	sensitive fine grained	UNDFND	UNDFO	3	.3
5.82	19	5.23	0.03	0.56	0.49	sensitive fine grained	UNDFND	UNDFO	3	.2
6.12	20	5.32	0.02	0.37	0.51	sensitive fine grained	UNDFND	UNDFD	3	.2
6.42	21	10.33	0.05	0.50	0.54	sandy silt to clayey silt	UNDFND	UNDFD	4	.5

Or - All sands (Jamiolkowski et al. 1985) PHI - Robertson and Campanella 1983 Su: Nk= 16

**** Note: For interpretation purposes the PLOTTEO CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.04) ****

SOUNDING DATA IN FILE JI0008 12-04-01 14:18

OPERATOR : AL MYERS LOCATION : CPT - 03

CONE ID : 416 JOB No. : JAMES ISLAND

E 2 C R

DEPTH meters	DEPTH feet	TIP Qc tsf	FRICTION Fs tsf	FR RATIO Fs/Qc %	PORE PR Pw psi	P P RATIO Pw/Qc %	DIFF P P RATIO (Pw-Ph)/Qc %	INC I deg	INTERPRETED SOIL TYPE	N SPT
4.60	15.1	5	0.02	0.48	25.9	38.84	29.03	0.1	?	?
4.65	15.3	5	0.02	0.47	26.4	40.28	30.19	0.1	sensitive fine grained	2
4.70	15.4	5	0.02	0.47	26.9	39.63	29.78	0.1	sensitive fine grained	2
4.75	15.6	5	0.02	0.47	27.3	39.24	29.54	0.1	sensitive fine grained	2
4.80	15.7	5	0.02	0.38	27.9	39.33	29.69	0.1	sensitive fine grained	2
4.85	15.9	5	0.02	0.42	28.3	40.70	30.79	0.1	sensitive fine grained	2
4.90	16.1	5	0.02	0.43	28.8	42.51	32.24	0.1	sensitive fine grained	2
4.95	16.2	5	0.02	0.41	29.6	41.83	31.89	0.1	sensitive fine grained	2
5.00	16.4	5	0.02	0.39	30.3	41.04	31.40	0.1	sensitive fine grained	3
5.05	16.6	6	0.02	0.42	31.3	39.57	30.49	0.1	sensitive fine grained	3
5.10	16.7	6	0.02	0.37	32.2	37.38	28.96	0.1	sensitive fine grained	3
5.15	16.9	6	0.02	0.34	33.2	37.24	29.02	0.1	sensitive fine grained	3
5.20	17.1	6	0.02	0.36	34.2	39.13	30.67	0.1	sensitive fine grained	3
5.25	17.2	6	0.02	0.36	35.0	39.32	30.94	0.1	sensitive fine grained	3
5.30	17.4	7	0.03	0.47	35.9	39.24	30.99	0.1	sensitive fine grained	3
5.35	17.6	6	0.03	0.40	36.5	42.32	33.48	0.1	sensitive fine grained	3
5.40	17.7	6	0.02	0.42	37.2	46.98	37.27	0.1	sensitive fine grained	3
5.45	17.9	6	0.03	0.49	37.3	45.49	36.04	0.1	sensitive fine grained	3
5.50	18.0	6	0.03	0.56	37.7	45.96	36.42	0.1	sensitive fine grained	3
5.55	18.2	5	0.03	0.68	38.2	54.87	43.53	0.1	sensitive fine grained	3
5.60	18.4	5	0.03	0.48	38.5	53.52	42.46	0.1	sensitive fine grained	2
5.65	18.5	5	0.03	0.53	38.8	54.73	43.38	0.1	sensitive fine grained	3
5.70	18.7	6	0.03	0.58	39.1	47.62	37.74	0.1	sensitive fine grained	3
5.75	18.9	5	0.03	0.57	39.2	55.39	43.84	0.1	sensitive fine grained	3
5.80	19.0	5	0.03	0.51	40.1	56.57	44.92	0.1	sensitive fine grained	2
5.85	19.2	5	0.02	0.44	40.7	54.29	43.19	0.1	sensitive fine grained	3
5.90	19.4	5	0.02	0.44	41.4	55.24	44.04	0.1	sensitive fine grained	3
5.95	19.5	6	0.02	0.42	42.1	54.06	43.20	0.1	sensitive fine grained	3
6.00	19.7	6	0.02	0.39	42.5	53.72	42.93	0.1	sensitive fine grained	3
6.05	19.8	5	0.02	0.29	43.1	56.63	45.33	0.1	sensitive fine grained	2
6.10	20.0	4	0.01	0.19	26.6	44.55	29.99	0.1	sensitive fine grained	3
6.15	20.2	7	0.01	0.18	26.6	29.45	19.76	0.1	sensitive fine grained	4
6.20	20.3	12	0.01	0.10	14.0	8.33	3.09	0.1	sensitive fine grained	4
6.25	20.5	7	0.01	0.15	12.0	11.67	3.01	0.1	sensitive fine grained	4
6.30	20.7	7	0.02	0.33	12.7	13.57	3.96	0.1	sensitive fine grained	4
6.35	20.8	11	0.05	0.48	13.4	8.70	2.84	0.1	sandy silt to clayey silt	5
6.40	21.0	18	0.20	1.08	14.3	5.65	2.05	0.1	?	?
6.45	21.2	16	?	?	12.8	5.92	1.68	0.1	?	?
6.50	21.3	77	?	?	12.9	1.20	0.34	0.1	?	?

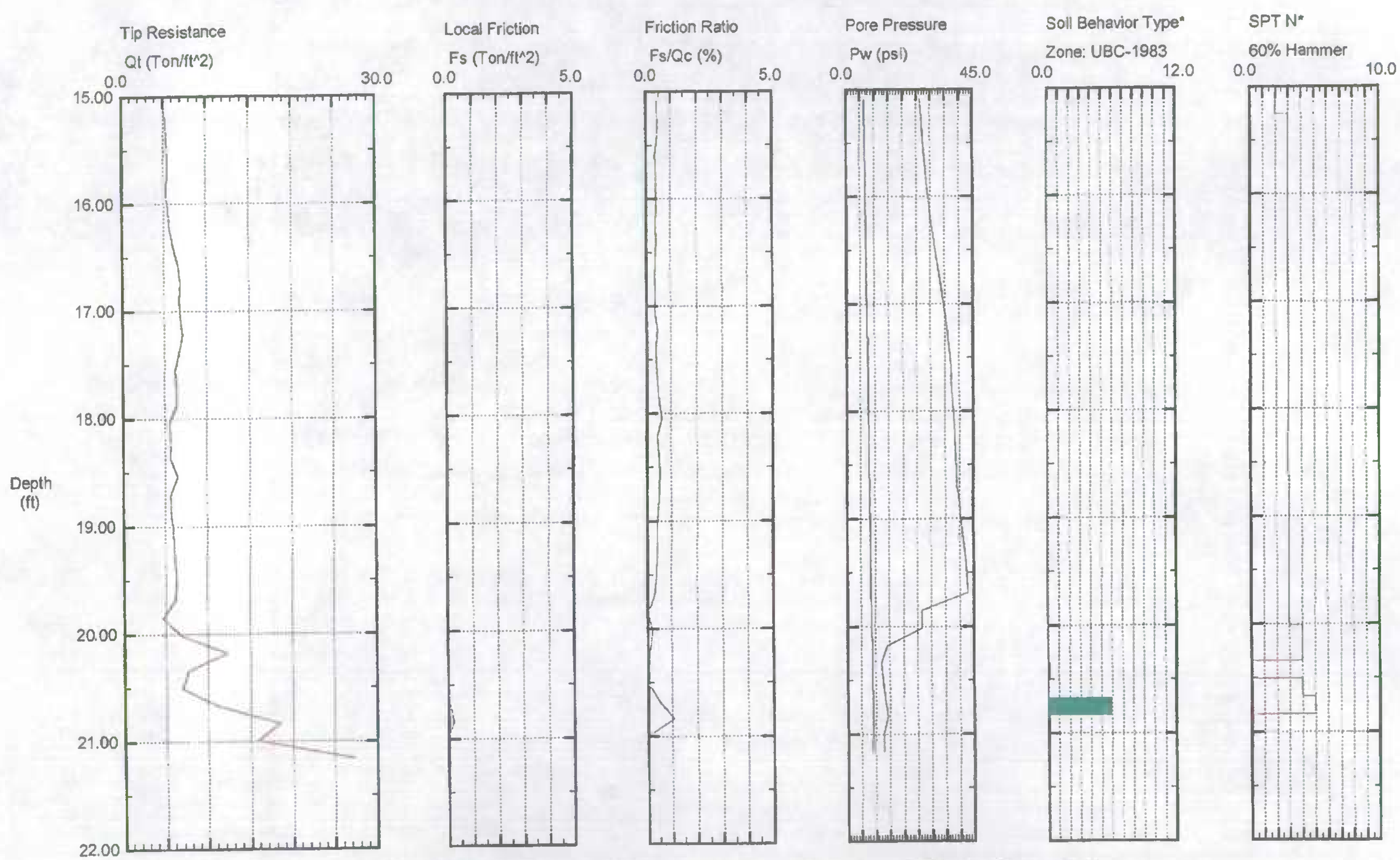
Soil interpretation reference: Robertson & Campanella-1983, based on 60% hammer efficiency and .15 m sliding data average

*Soil behavior type and SPT based on data from UBC-1983

E2CR

Operator: AL MYERS
Sounding: JI0008
Cone Used: 416

CPT Date/Time: 12-04-01 14:18
Location: CPT - 03
Job Number: JAMES ISLAND



Maximum Depth = 21.16 feet

Depth Increment = 0.16 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

1 E 2 C R
0

Operator :AL MYERS
On Site Loc:CPT - 04
Job No. :JAMES ISLAND
Tot. Unit Wt. (avg) : 115 pcf

CPT Date :12-04-01 11:50
Cone Used :416
Water table (feet) : 0

DEPTH (meters)	(feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
4.26	14	2.37	0.03	1.27	0.18	sensitive fine grained	UNDFND	UNDFD	1	.1
4.56	15	7.03	0.02	D.24	0.38	sensitive fine grained	UNDFNO	UNDFD	3	.3
4.91	16	7.27	0.01	0.13	0.41	sensitive fine grained	UNDFND	UNOFO	3	.3
5.21	17	8.35	0.01	D.15	0.44	sensitive fine grained	UNDFND	UNDFD	4	.4
5.51	18	9.33	0.02	0.18	0.46	sensitive fine grained	UNDFNO	UNDFD	4	.5

Dr - All sands (Jamiolkowski et al. 1985) PHI - Robertson and Campanella 1983 Su: Nk= 16

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATEO OUTPUT from CPTINTR1 (v 3.04) ****

SOUNDING DATA IN FILE JI0007 12-04-01 11:50

OPERATOR : AL MYERS LOCATION : CPT - 04

CONE ID : 416 JOB No. : JAMES ISLAND

E 2 C R

DEPTH meters	DEPTH feet	TIP Qc tsf	FRICTION Fs tsf	FR RATIO Fs/Qc %	PORE PR Pw psi	P P RATIO Pw/Qc %	DIFF P P RATIO (Pw-Ph)/Qc %	INC I deg	INTERPRETED SOIL TYPE	N SPT
4.00	13.1	1	0.02	1.20	1.0	5.02	-22.52	0.1	?	?
4.05	13.3	2	0.03	1.68	1.0	4.26	-21.42	0.1	sensitive fine grained	1
4.10	13.5	1	0.03	2.18	1.2	7.02	-28.28	0.1	sensitive fine grained	1
4.15	13.6	3	0.03	1.11	1.1	2.93	-12.23	0.1	sensitive fine grained	1
4.20	13.8	3	0.04	1.06	1.3	2.67	-9.98	0.1	sensitive fine grained	2
4.25	13.9	4	0.04	1.16	1.4	2.73	-9.04	0.1	sensitive fine grained	2
4.30	14.1	4	0.04	0.84	1.5	2.56	-7.70	0.1	sensitive fine grained	2
4.35	14.3	5	0.02	0.50	1.5	2.26	-7.02	0.2	sensitive fine grained	2
4.40	14.4	6	0.02	0.26	1.6	1.89	-5.28	0.1	sensitive fine grained	3
4.45	14.6	9	0.01	0.13	1.8	1.46	-3.77	0.1	sensitive fine grained	4
4.50	14.8	9	0.01	0.06	2.0	1.60	-3.64	0.1	sensitive fine grained	4
4.55	14.9	9	0.01	0.11	4.9	3.83	-1.18	0.1	sensitive fine grained	4
4.60	15.1	8	0.01	0.14	5.0	4.38	-1.30	0.1	sensitive fine grained	4
4.65	15.3	8	0.01	0.14	5.2	4.73	-1.30	0.1	sensitive fine grained	4
4.70	15.4	7	0.01	0.16	5.2	5.07	-1.44	0.1	sensitive fine grained	4
4.75	15.6	7	0.01	0.13	5.4	5.75	-1.40	0.1	sensitive fine grained	3
4.80	15.7	7	0.01	0.12	5.4	5.85	-1.61	0.1	sensitive fine grained	3
4.85	15.9	7	0.01	0.09	5.5	5.91	-1.49	0.1	sensitive fine grained	3
4.90	16.1	7	0.01	0.14	5.6	5.61	-1.38	0.1	sensitive fine grained	3
4.95	16.2	8	0.01	0.11	5.8	5.51	-1.16	0.1	sensitive fine grained	4
5.00	16.4	8	0.01	0.15	5.7	5.17	-1.31	0.1	sensitive fine grained	4
5.05	16.6	8	0.01	0.17	6.0	5.36	-1.01	0.1	sensitive fine grained	4
5.10	16.7	8	0.01	0.10	6.0	5.17	-1.04	0.1	sensitive fine grained	4
5.15	16.9	9	0.01	0.15	6.3	5.01	-0.85	0.1	sensitive fine grained	4
5.20	17.1	9	0.02	0.22	6.3	5.03	-0.83	0.1	sensitive fine grained	4
5.25	17.2	9	0.03	0.29	6.5	4.99	-0.73	0.1	sensitive fine grained	5
5.30	17.4	11	0.01	0.13	6.7	4.51	-0.55	0.1	sandy silt to clayey silt	4
5.35	17.6	11	0.01	0.13	6.8	4.47	-0.51	0.1	sensitive fine grained	5
5.40	17.7	8	0.01	0.17	7.3	6.19	-0.32	0.1	sensitive fine grained	4
5.45	17.9	8	0.02	0.28	7.5	6.59	-0.21	0.1	sensitive fine grained	4
5.50	18.0	8	0.01	0.13	7.7	6.79	-0.08	0.1	sensitive fine grained	4
5.55	18.2	10	0.01	0.09	8.0	5.81	0.07	0.1	sensitive fine grained	5
5.60	18.4	12	0.01	0.09	8.5	5.30	0.32	0.1	?	?
5.65	18.5	11	?	?	8.7	5.55	0.43	0.1	?	?
5.70	18.7	55	?	?	9.5	1.23	0.18	0.1	?	?

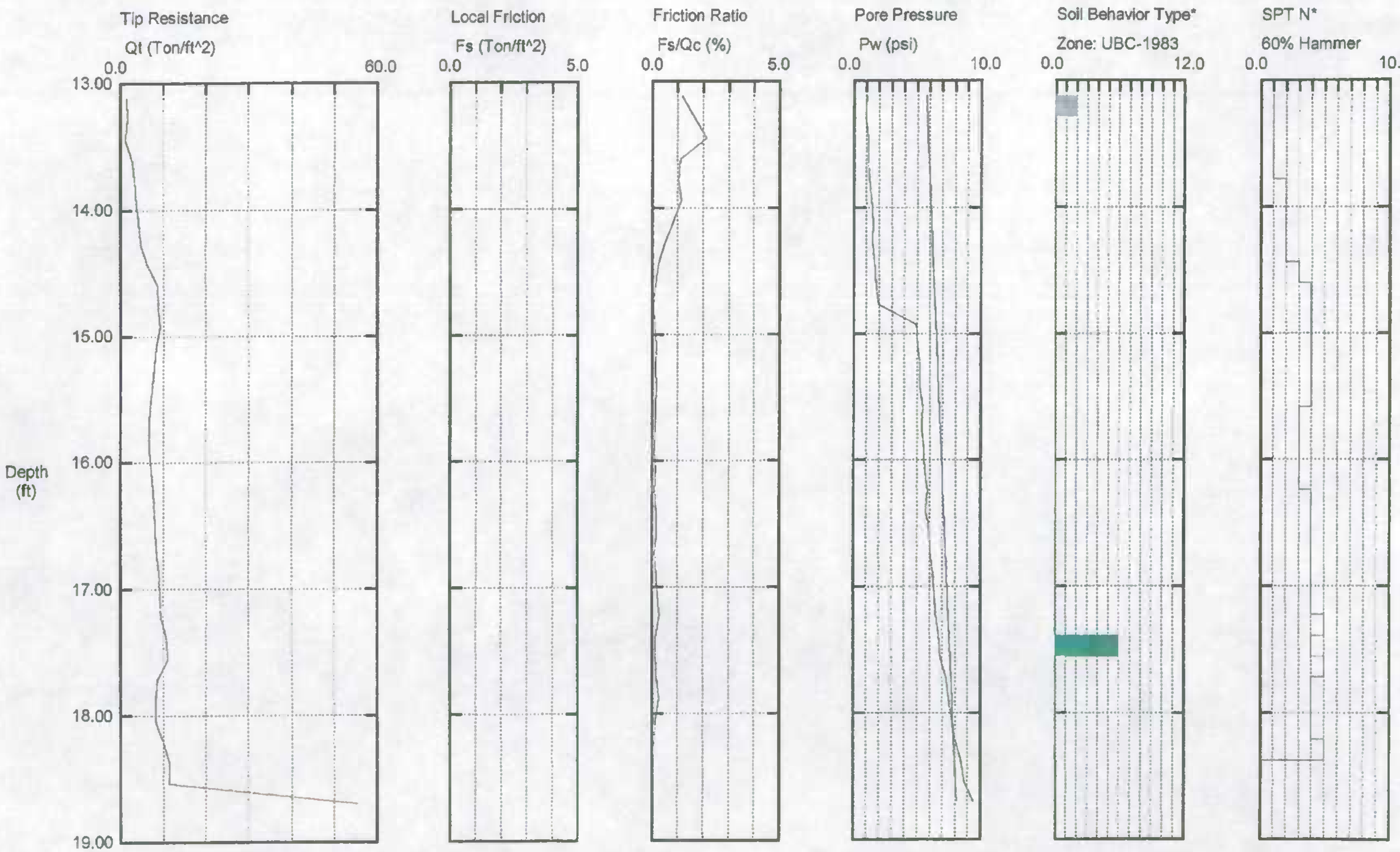
Soil interpretation reference: Robertson & Campanella-1983, based on 60% hammer efficiency and .15 m sliding data average

*Soil behavior type and SPT based on data from UBC-1983

E2CR

Operator: AL MYERS
Sounding: JI0007
Cone Used: 416

CPT Date/Time: 12-04-01 11:50
Location: CPT - 04
Job Number: JAMES ISLAND



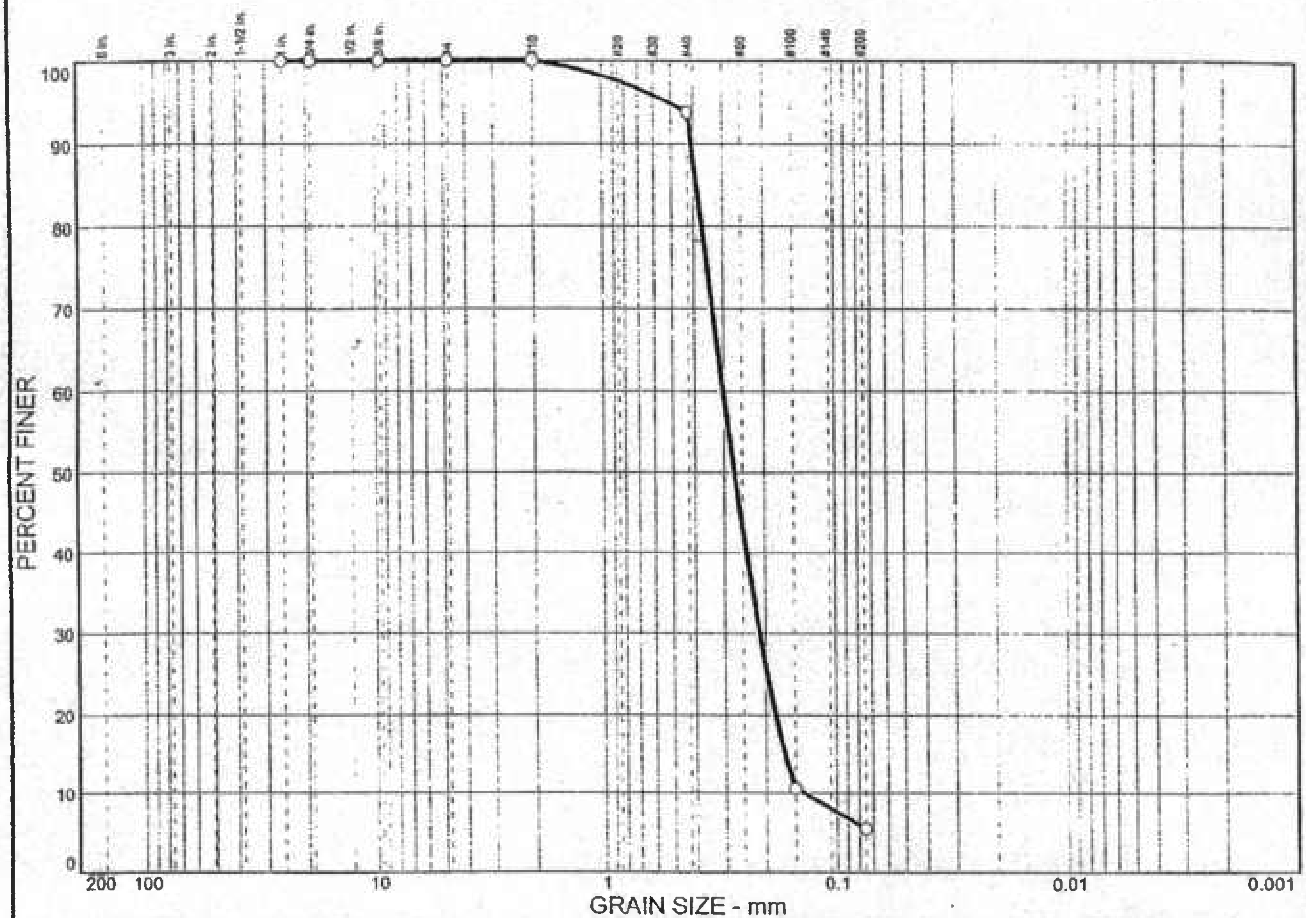
Maximum Depth = 18.70 feet

Depth Increment = 0.16 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

Appendix E
Laboratory Testing Data

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	6.2	88.3	5.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.389	0.302	0.271	0.212	0.166	0.138	1.08	2.18

MATERIAL DESCRIPTION	USCS	AASHTO
○ Orange Brown,Poorly graded SAND,trace Silt	SP-SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

○ **Source:** JB 3 **Sample No.:** S-3 **Elev./Depth:** 13.0'-15.0'

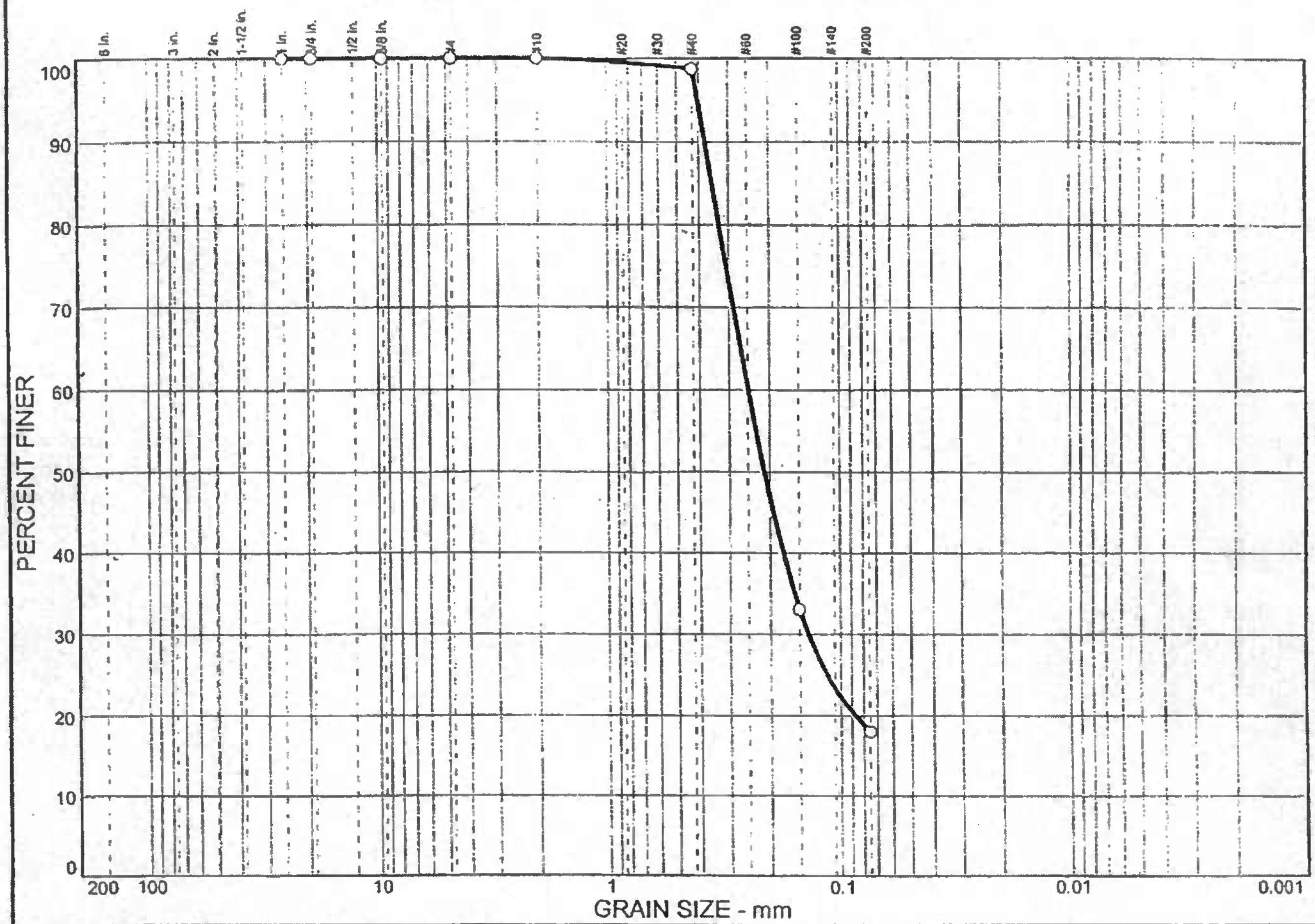
Remarks:
○ Natural Moisture = 23.1%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
o	0.0	0.0	0.0	0.0	1.2	80.8	18.0	

X	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
o			0.354	0.248	0.211	0.137				

MATERIAL DESCRIPTION	USCS	AASHTO
o M.Reddish Gray,Silty Fine SAND,trace Shell	SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

o **Source:** JB 1 **Sample No.:** S-3 **Elev./Depth:** 13.0'-15.0'

Remarks:

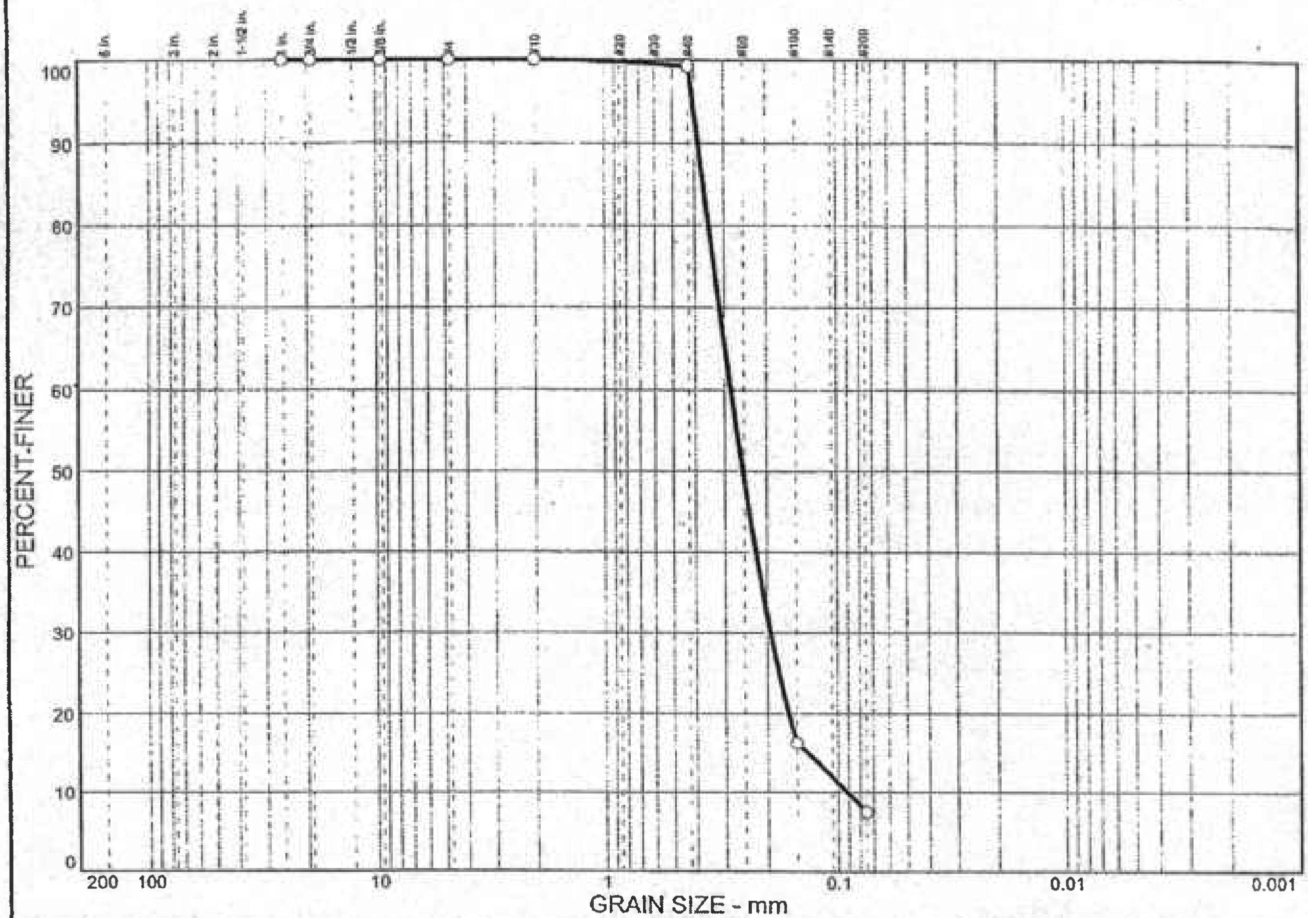
o Natural Moisture = 31.7%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○ 0.0	0.0	0.0	0.0	0.7	91.8	7.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.368	0.283	0.253	0.194	0.135	0.0913	1.46	3.10

MATERIAL DESCRIPTION	USCS	AASHTO
○ L.Orange Brown,Poorly Graded SAND,trace Silt	SP-SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

○ **Source:** JB 4 **Sample No.:** S-2 **Elev./Depth:** 12.0'-14.0'

Remarks:

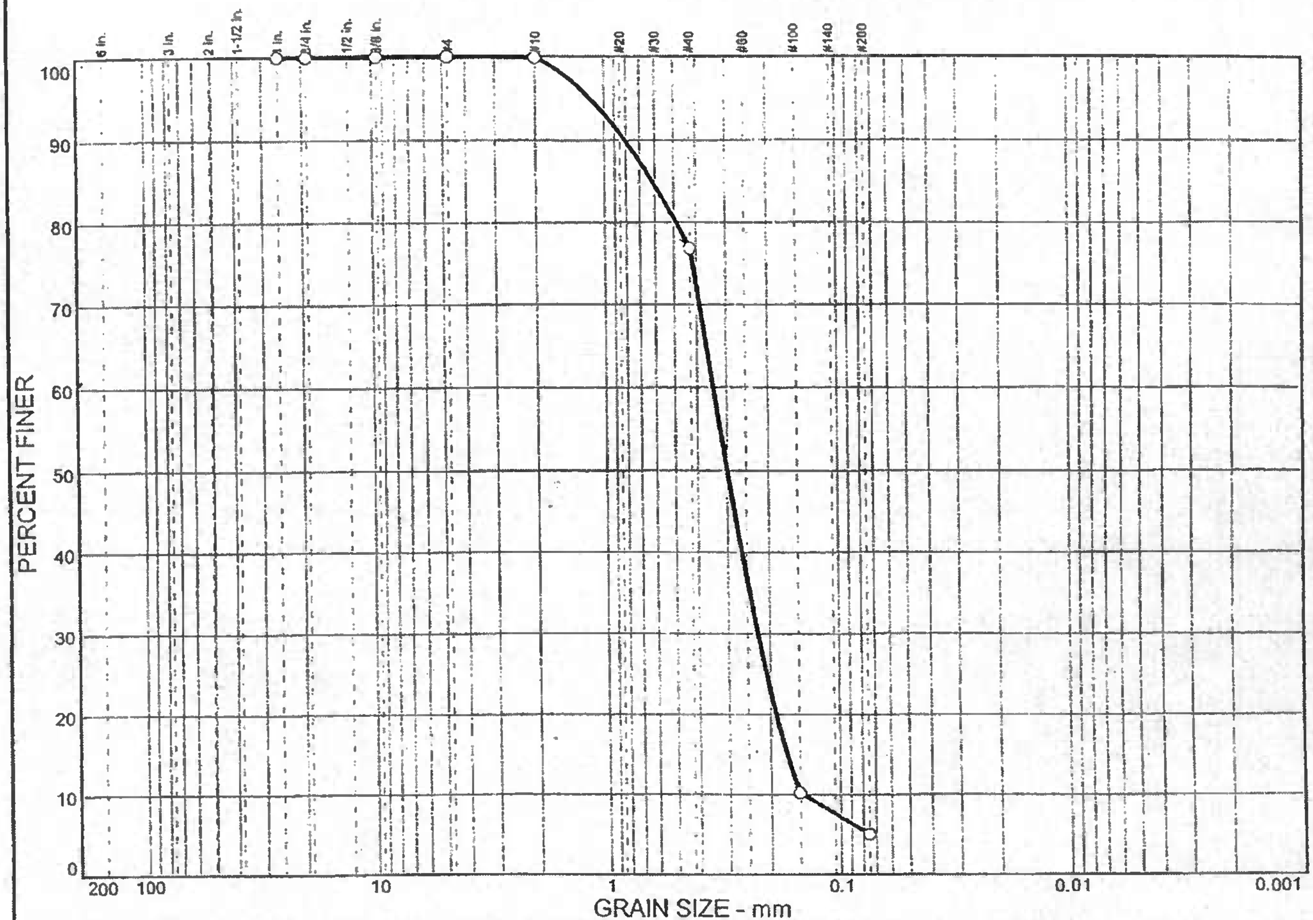
○Natural Moisture = 28.1%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.1	23.1	71.8	5.0	

X	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.616	0.342	0.300	0.226	0.171	0.146	1.02	2.34

MATERIAL DESCRIPTION	USCS	AASHTO
○ Gray,Poorly Graded SAND,trace Silt	SP-SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

○ **Source:** JB 4 **Sample No.:** S-10 **Elev./Depth:** 38.5'-40.0'

Remarks:

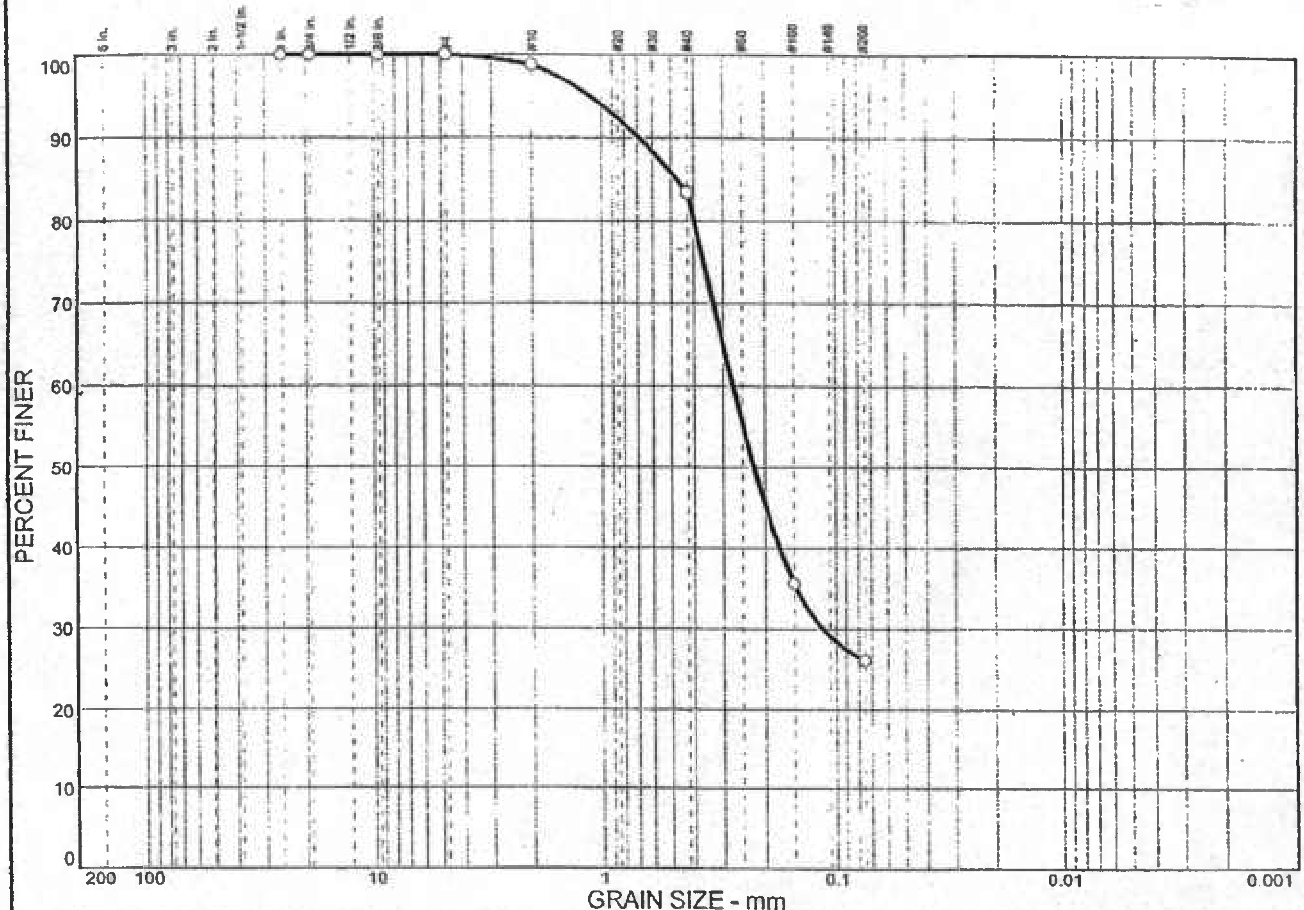
○Natural Moisture = 19.3%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	1.2	15.3	57.4	26.1	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.470	0.273	0.222	0.114				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Greenish Gray,Silty,Clayey SAND	SC-SM	

Project No. 01572-04 **Client:** G B A
Project: James Island

○ **Source:** JB 4 **Sample No.:** S-12 **Elev./Depth:** 48.5'-50.0'

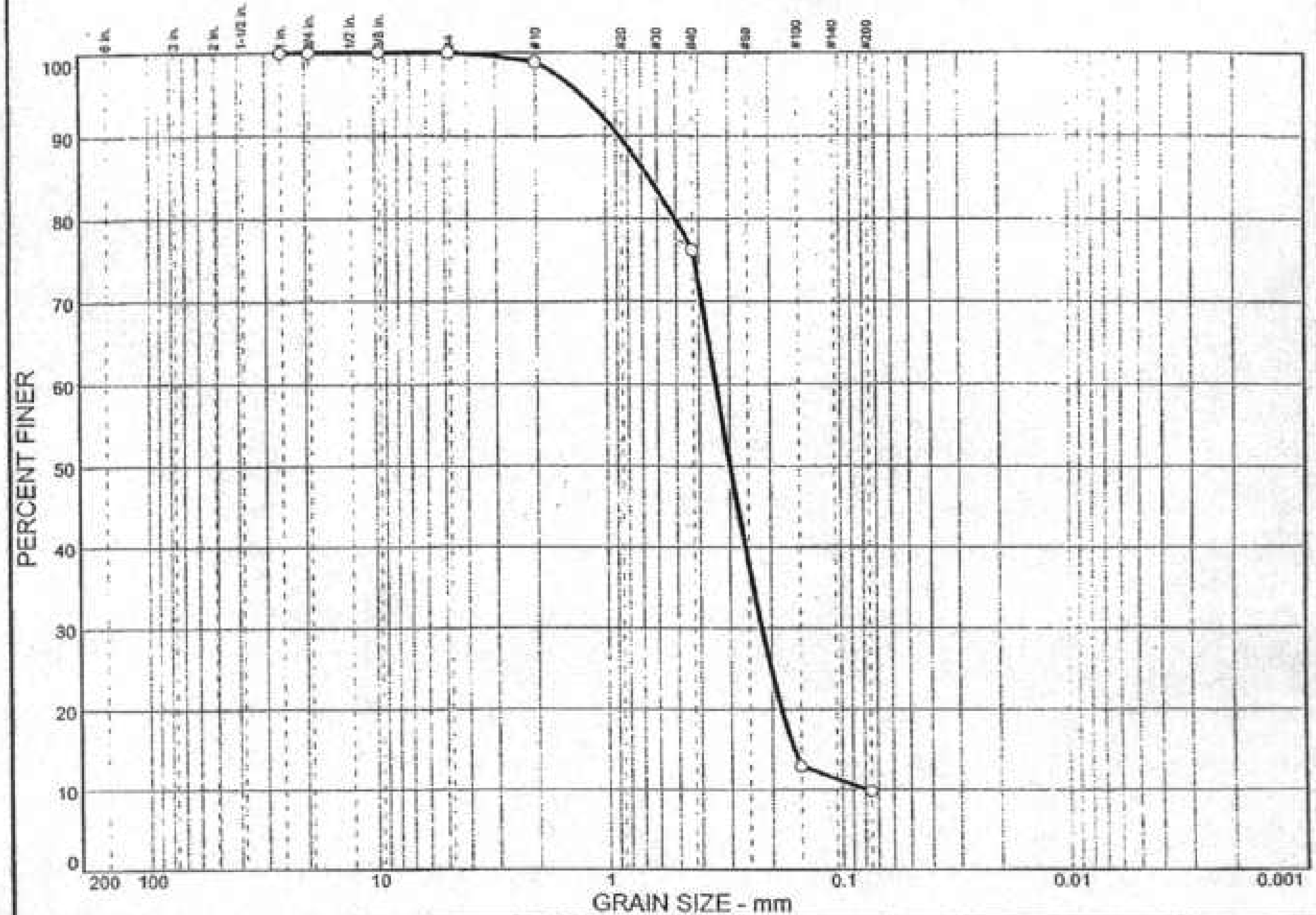
Remarks:
○Natural Moisture = 22.8%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	1.1	22.7	66.4	9.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.647	0.342	0.298	0.220	0.160	0.0784	1.81	4.36

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brown Gray,Poorly Graded SAND,trace Silt	SP-SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

○ **Source:** JB 4 **Sample No.:** S-11 **Elev./Depth:** 43.5'-45.0'

Remarks:

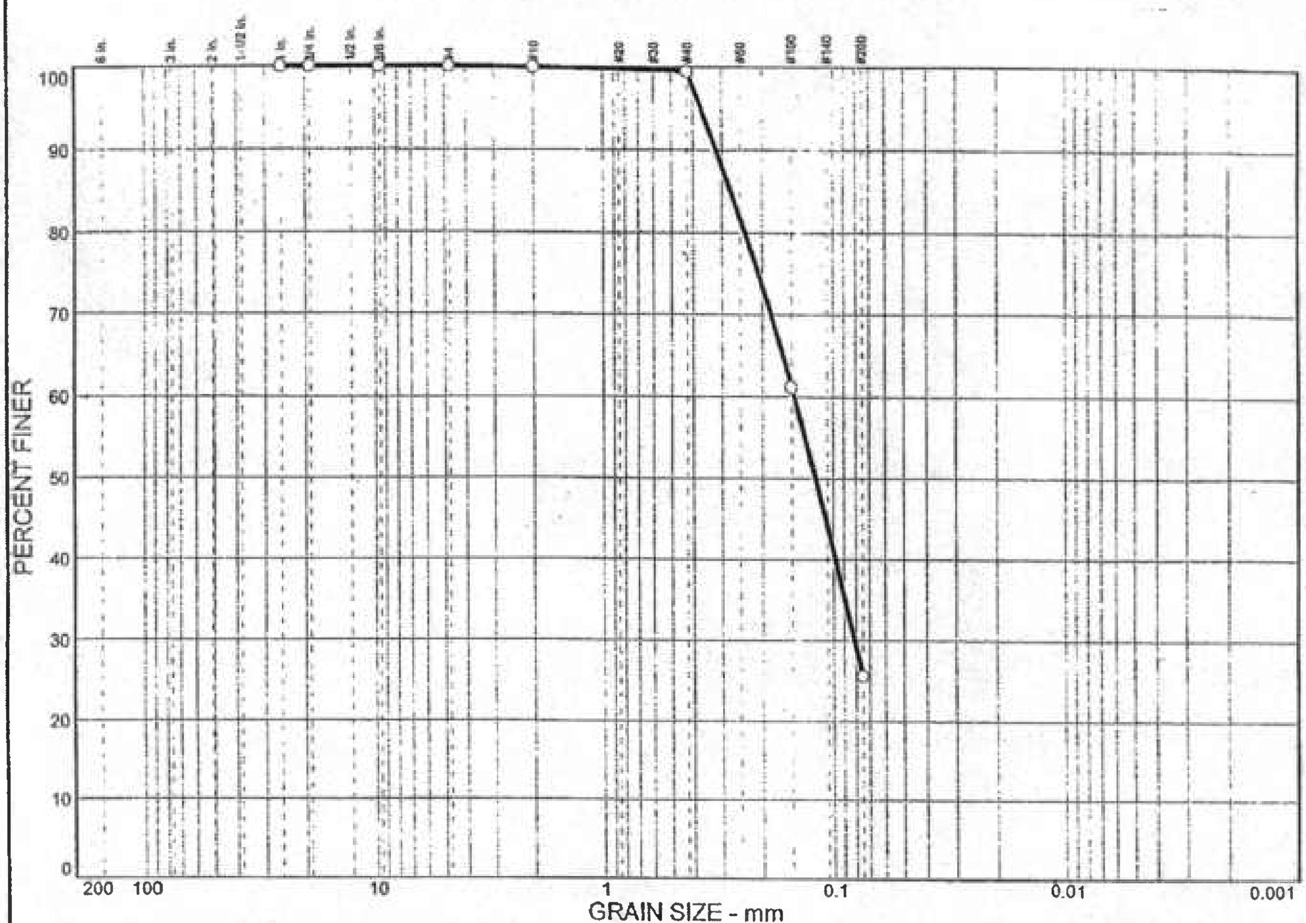
○Natural Moisture = 18.0%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.1	0.4	73.9	25.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.274	0.146	0.119	0.0813				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Graysh green,Silty Fine SAND,trace Clay	SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

○ **Source:** JB 5 **Sample No.:** S-8 **Elev./Depth:** 28.5'-30.0'

Remarks:

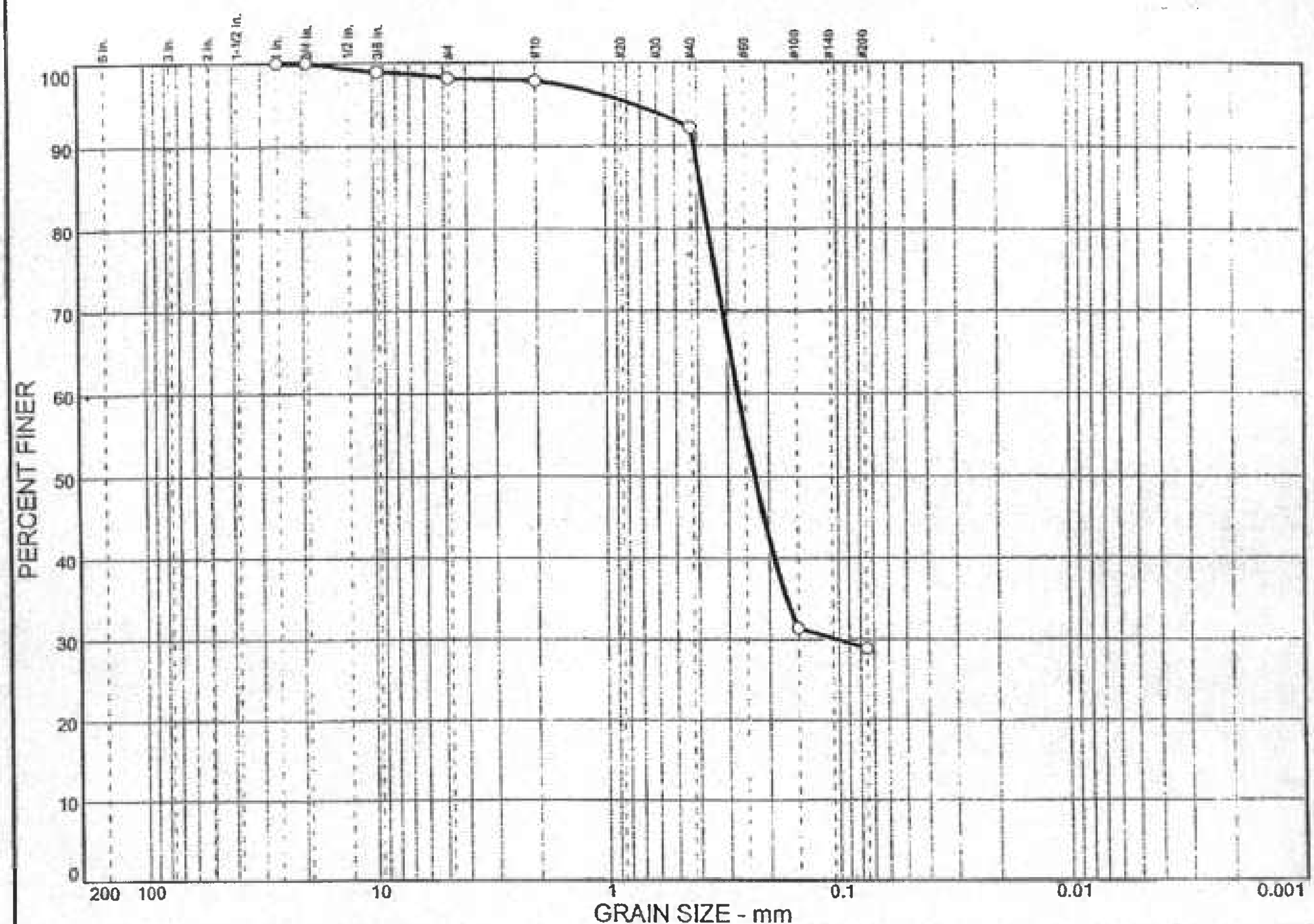
○natural Moisture = 30.9%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	1.9	0.3	5.6	63.3	28.9	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.386	0.271	0.230	0.102				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brownish Gray,Clayey F-M SAND,trace Gravel	SC	

Project No. 01572-04 **Client:** G B A
Project: James Island

○ **Source:** JB 10 **Sample No.:** S-7 **Elev./Depth:** 22.0'-23.0'

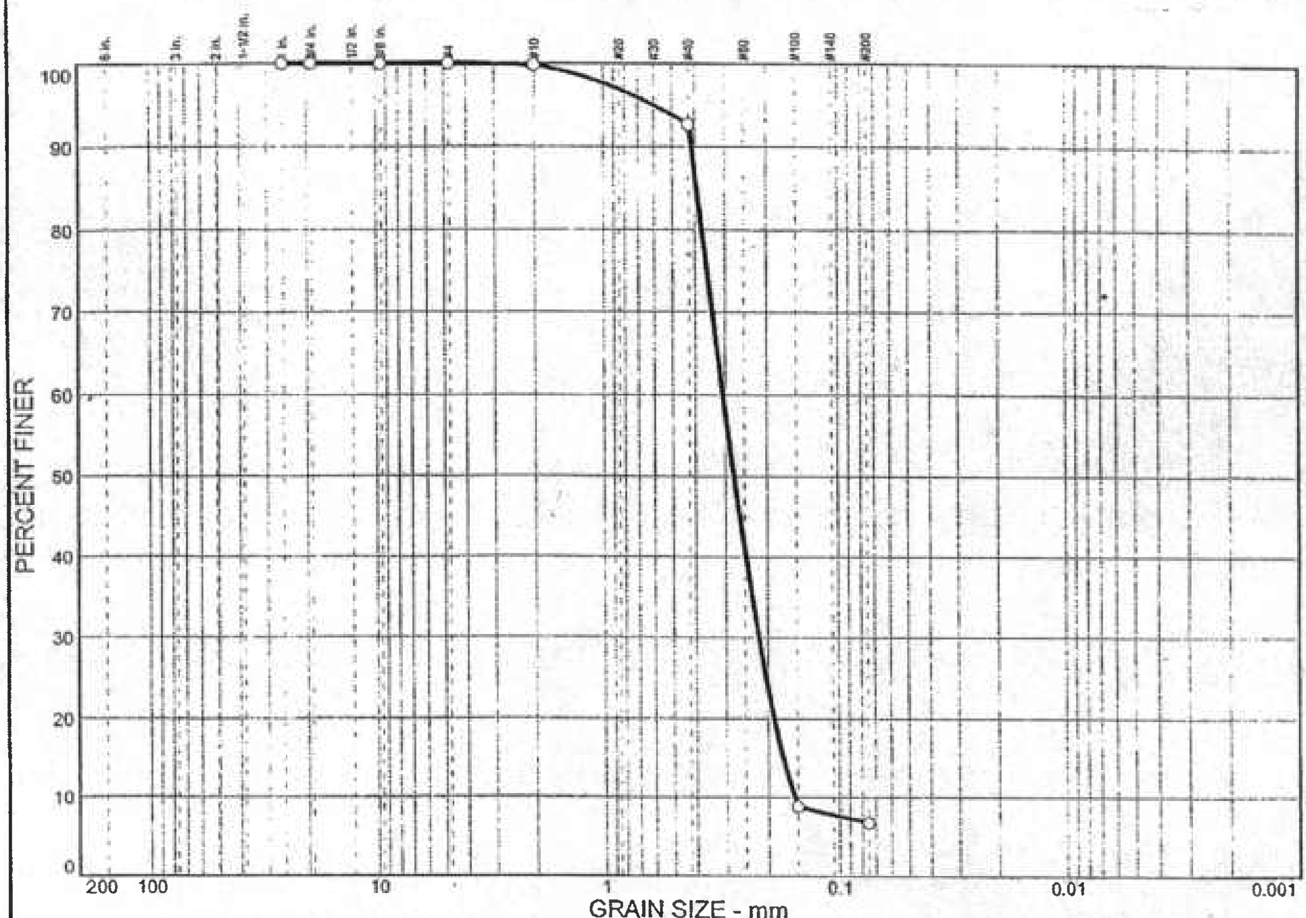
Remarks:
○ Natural Moisture= 22.7%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.2	7.1	85.9	6.8	

X	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.394	0.308	0.277	0.218	0.173	0.155	1.00	1.98

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brownish Gray,Poorly Graded SAND,trace Fine	SP-SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

○ **Source:** JB 10 **Sample No.:** S-8 **Elev./Depth:** 23.5'-25.0'

Remarks:

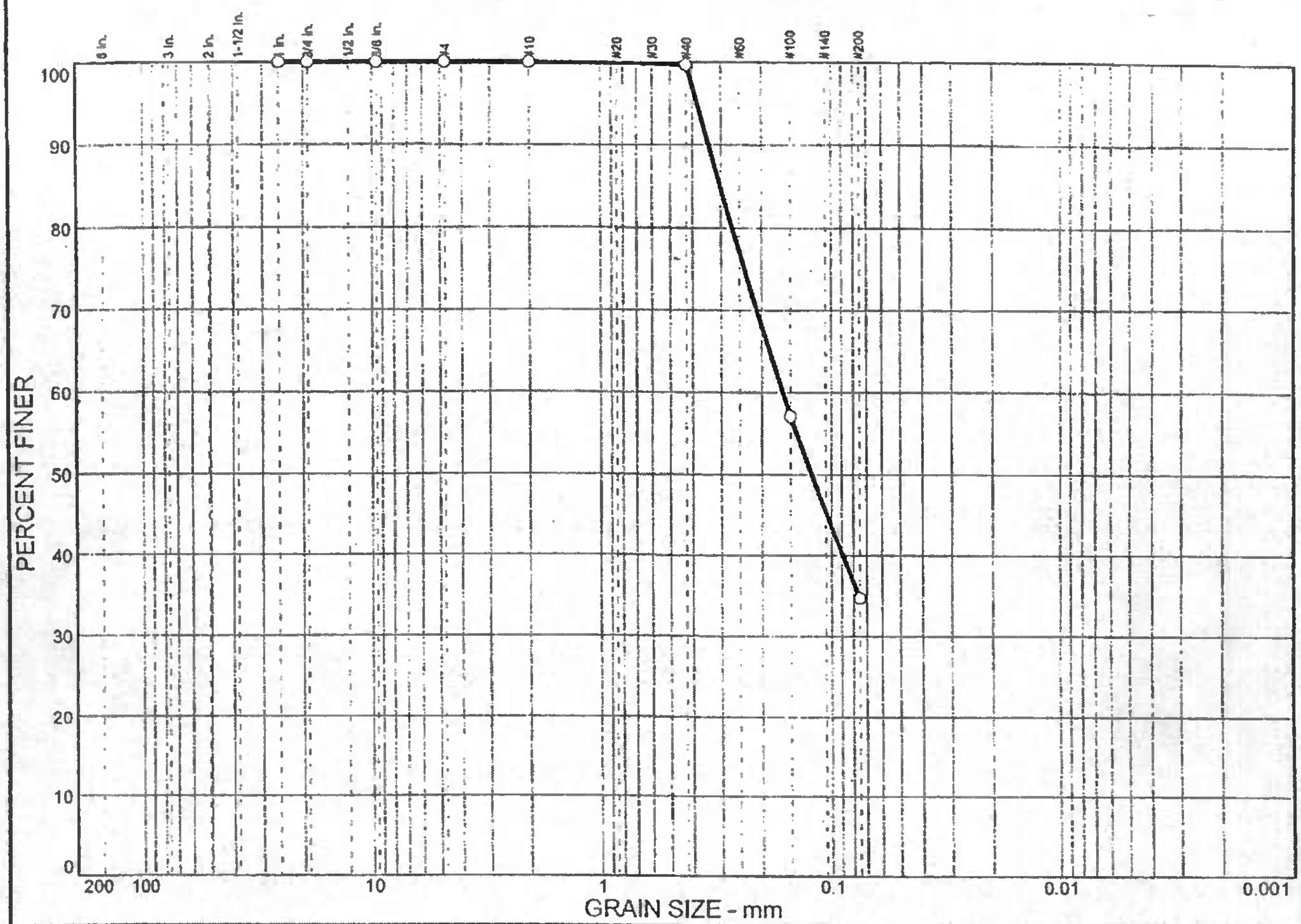
○Natural Moisture = 22.1%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.3	65.0	34.7	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.302	0.162	0.122					

MATERIAL DESCRIPTION	USCS	AASHTO
○ L.Greenish Brown,Clayey Fine SAND	SC	

Project No. 01572-04 **Client:** G B A

Project: James Island

○ **Source:** JB 10 **Sample No.:** S-13 **Elev./Depth:** 48.5'-50.0'

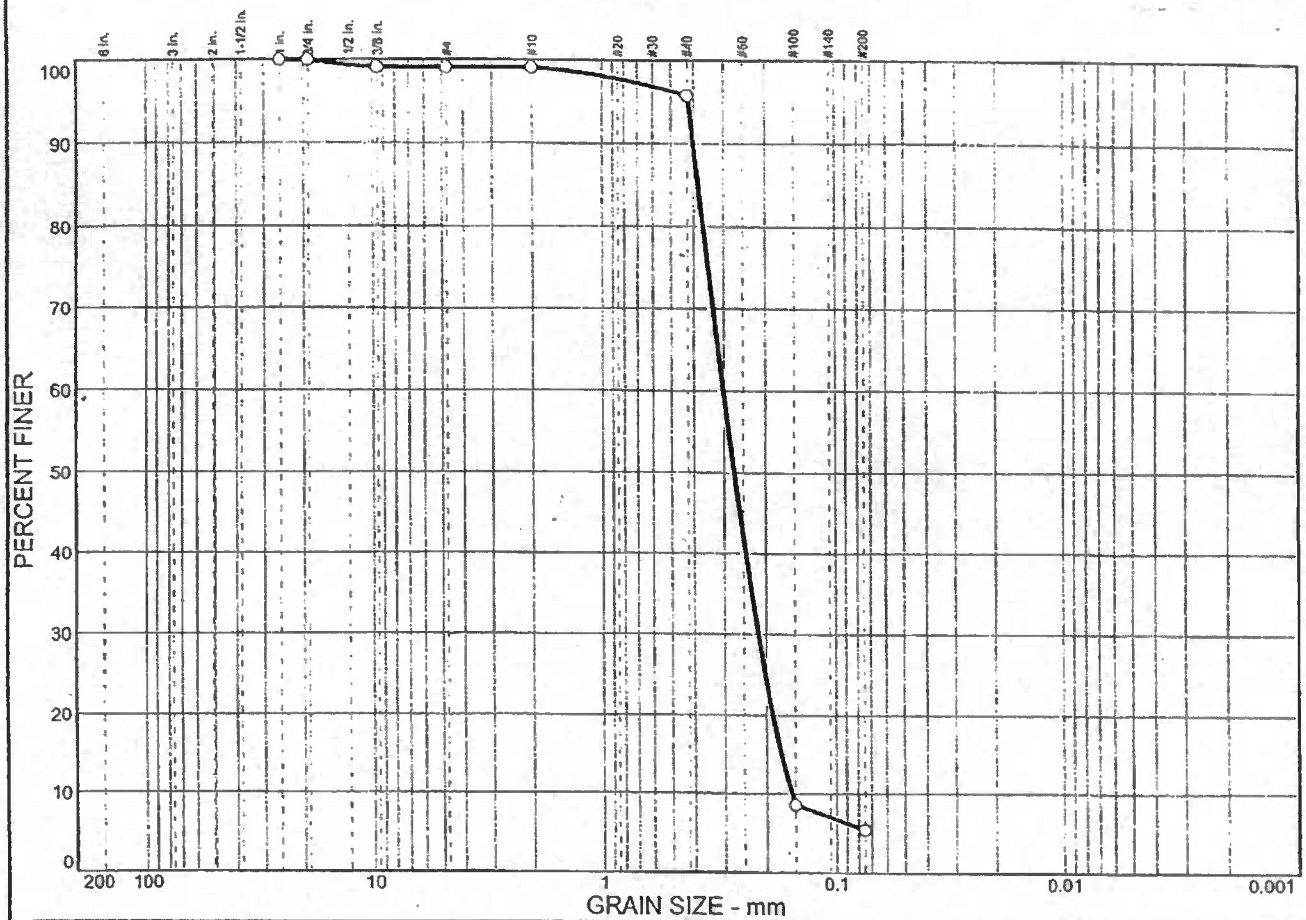
Remarks:
○Natural Moisture = 33.5%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
o	0.0	0.0	0.9	0.0	3.3	90.3	5.5	

X	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
o			0.384	0.302	0.272	0.216	0.173	0.156	1.00	1.94

MATERIAL DESCRIPTION	USCS	AASHTO
o Grayish Brown,Poorly Graded SAND,trace Fines	SP-SM	

Project No. 01572-04 **Client:** G B A

Project: James Island

o **Source:** JB 11 **Sample No.:** S-7 **Elev./Depth:** 28.5'-30.0'

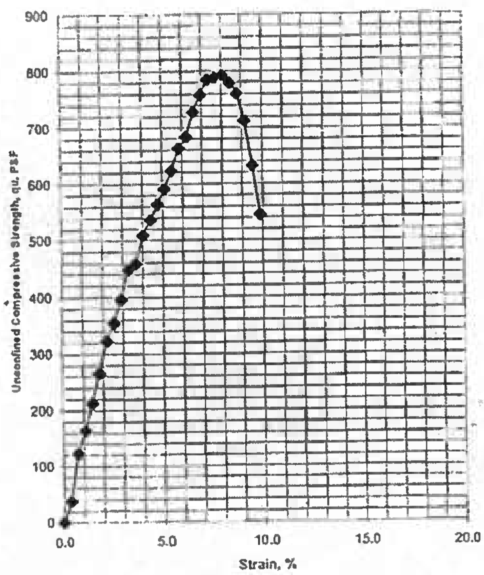
Remarks:

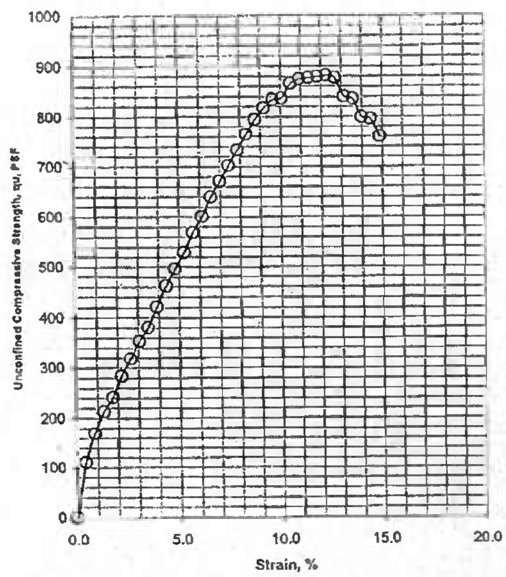
o Natural Moisture = 24.2%

Particle Size Distribution Report

E2CR, Inc.

Plate





Boring No.	JB-7	
Depth	21-22	FEET
Diameter, D	2.8	INCH
Length, L	6.8	INCH
L/D Ratio	2.4	
q_u	792	PSF
W.C.	38.7	%
Dry density	83.1	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Greenish Gray,Clayey SAND

Sketch at Failure:

Boring No.	JB-7	
Depth	22-23	FEET
Diameter, D	2.9	INCH
Length, L	5.7	INCH
L/D Ratio	2.0	
q_u	881	PSF
W.C.	32.1	%
Dry density	88.4	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Greenish Gray,Clayey SAND

Sketch at Failure:

Project Name:	James Island	Date:	1/7/02
Project No.:	01572-04	Figure:	

UNCONFINED COMPRESSION

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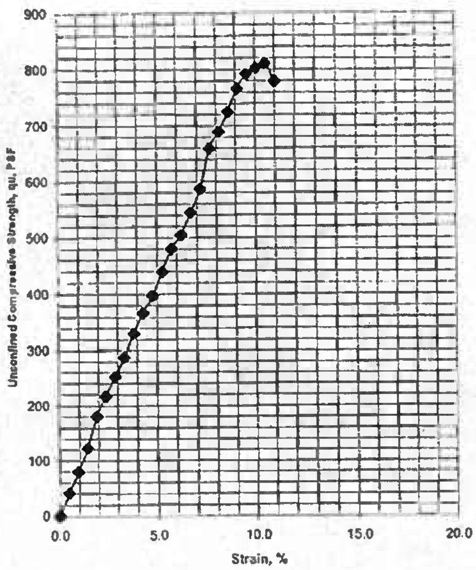
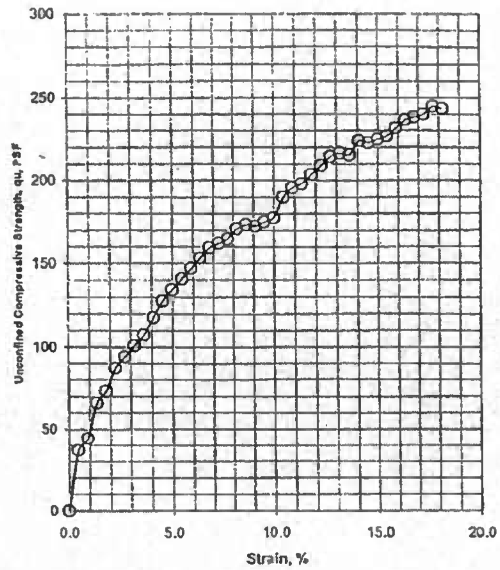
CONSTRUCTION - REMEDIATION -

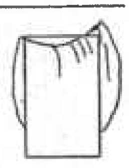




Boring No.	JB-9	
Depth	20-21	FEET
Diameter, D	2.7	INCH
Length, L	5.2	INCH
L/D Ratio	1.9	
q_u	810	PSF
W.C.	51.7	%
Dry density	68.9	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Grenish Gray, Silty CLAY

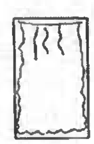
Sketch at Failure:



Boring No.	JB-11	
Depth	22-23.2	FEET
Diameter, D	2.9	INCH
Length, L	5.5	INCH
L/D Ratio	1.9	
q_u	245	PSF
W.C.	32.4	%
Dry density	91.3	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Greenish Gray,Silty CLAY,some Sand

Sketch at Failure:



Project Name:	James Island	Date:	12/21/01
Project No.:	01572-04	Figure:	

UNCONFINED COMPRESSION

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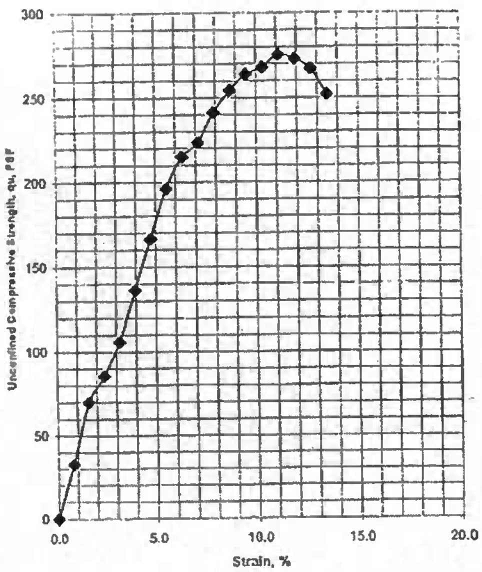
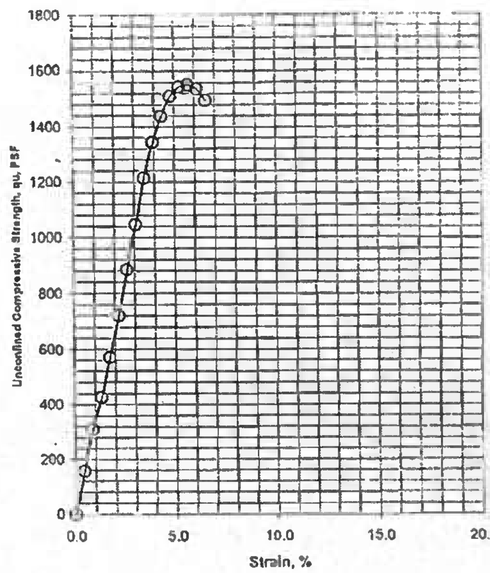
E2CR inc.
CONSTRUCTION · REMEDIATION ·

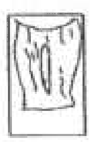




Boring No.	JB-12	
Depth	18-20	FEET
Diameter, D	2.9	INCH
Length, L	3.2	INCH
L/D Ratio	1.1	
q_u	275	PSF
W.C.	39.7	%
Dry density	79.3	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Greenish Gray, Sandy Silty CLAY

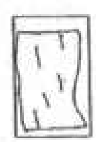
Sketch at Failure:



Boring No.	JB-15	
Depth	15-17	FEET
Diameter, D	2.9	INCH
Length, L	5.7	INCH
L/D Ratio	2.0	
q_u	1550	PSF
W.C.	52.0	%
Dry density	70.2	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Greenish Gray,Flat CLAY

Sketch at Failure:



Project Name:	James Island	Date:	1/16/02
Project No.:	01572-04	Figure:	

UNCONFINED COMPRESSION

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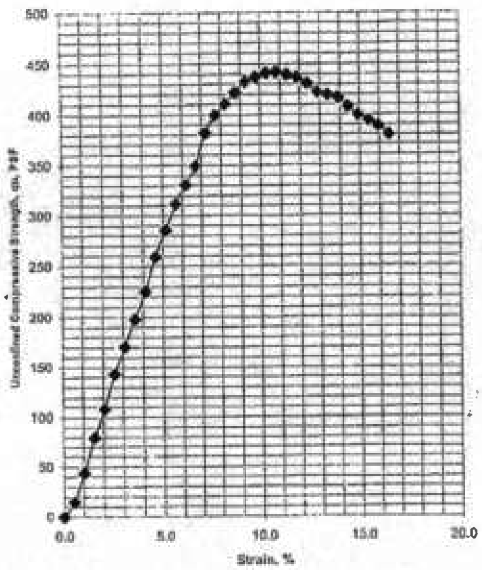
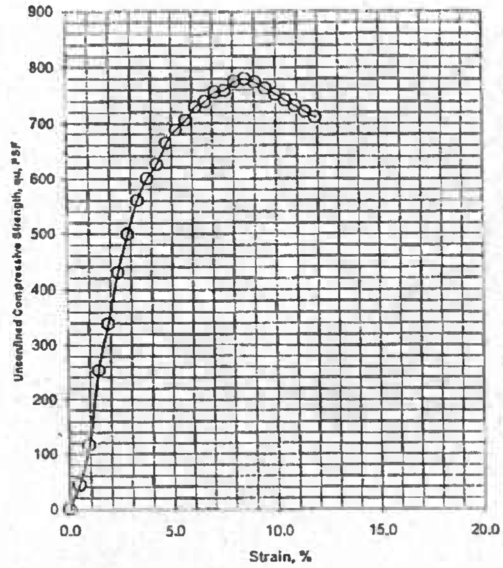
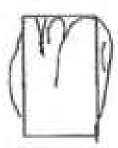




Boring No.	JB-19	
Depth	40-42	FEET
Diameter, D	2.9	INCH
Length, L	4.9	INCH
L/D Ratio	1.7	
q_u	442	PSF
W.C.	29.5	%
Dry density	93.1	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Greenish Gray, Silty SAND,trace Clay

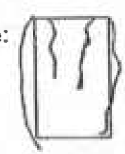
Sketch at Failure:



Boring No.	JB-20	
Depth	31-33	FEET
Diameter, D	2.9	INCH
Length, L	5.3	INCH
L/D Ratio	1.8	
q_u	780	PSF
W.C.	40.5	%
Dry density	83.9	PCF
Void Ratio		
q_{ur}		PSF
Sensitivity		
Liquid Limit		%
Plasticity Index		%

Description:
Greenish Gray,Silty CLAY

Sketch at Failure:



Project Name:	James Island	Date:	12/6/01
Project No.:	01572-04	Figure:	

UNCONFINED COMPRESSION

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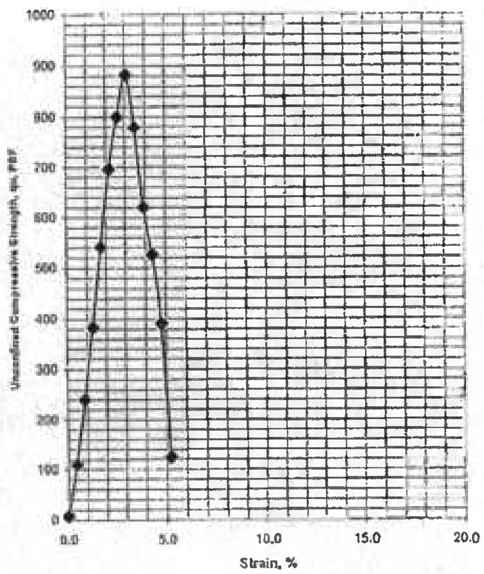
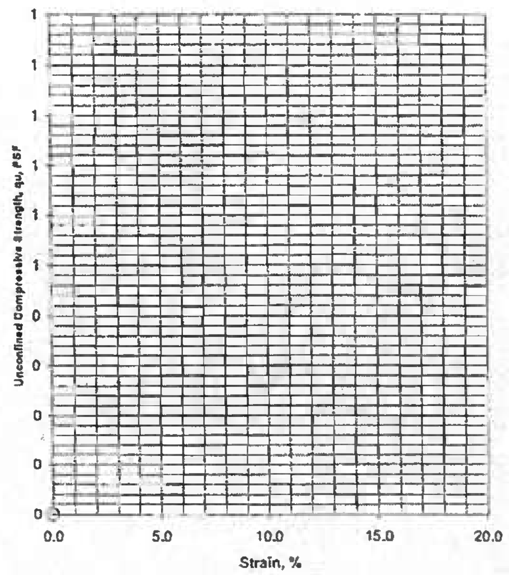


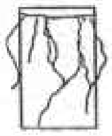


Boring No.	JB-21		Boring No.		
Depth	16-18	FEET	Depth		FEET
Diameter, D	2.9	INCH	Diameter, D		INCH
Length, L	5.7	INCH	Length, L		INCH
L/D Ratio	2.0		L/D Ratio		
q_u	882	PSF	q_u		PSF
W.C.	24.5	%	W.C.		%
Dry density	94.1	PCF	Dry density		PCF
Void Ratio			Void Ratio		
q_{ur}		PSF	q_{ur}		PSF
Sensitivity			Sensitivity		
Liquid Limit		%	Liquid Limit		%
Plasticity Index		%	Plasticity Index		%

Description:
Orange to Greenish Brown,Silty CLAY

Description:

Sketch at Failure:



Sketch at Failure:

Project Name:	James Island	Date:	1/7/02
Project No.:	01572-04	Figure:	

UNCONFINED COMPRESSION

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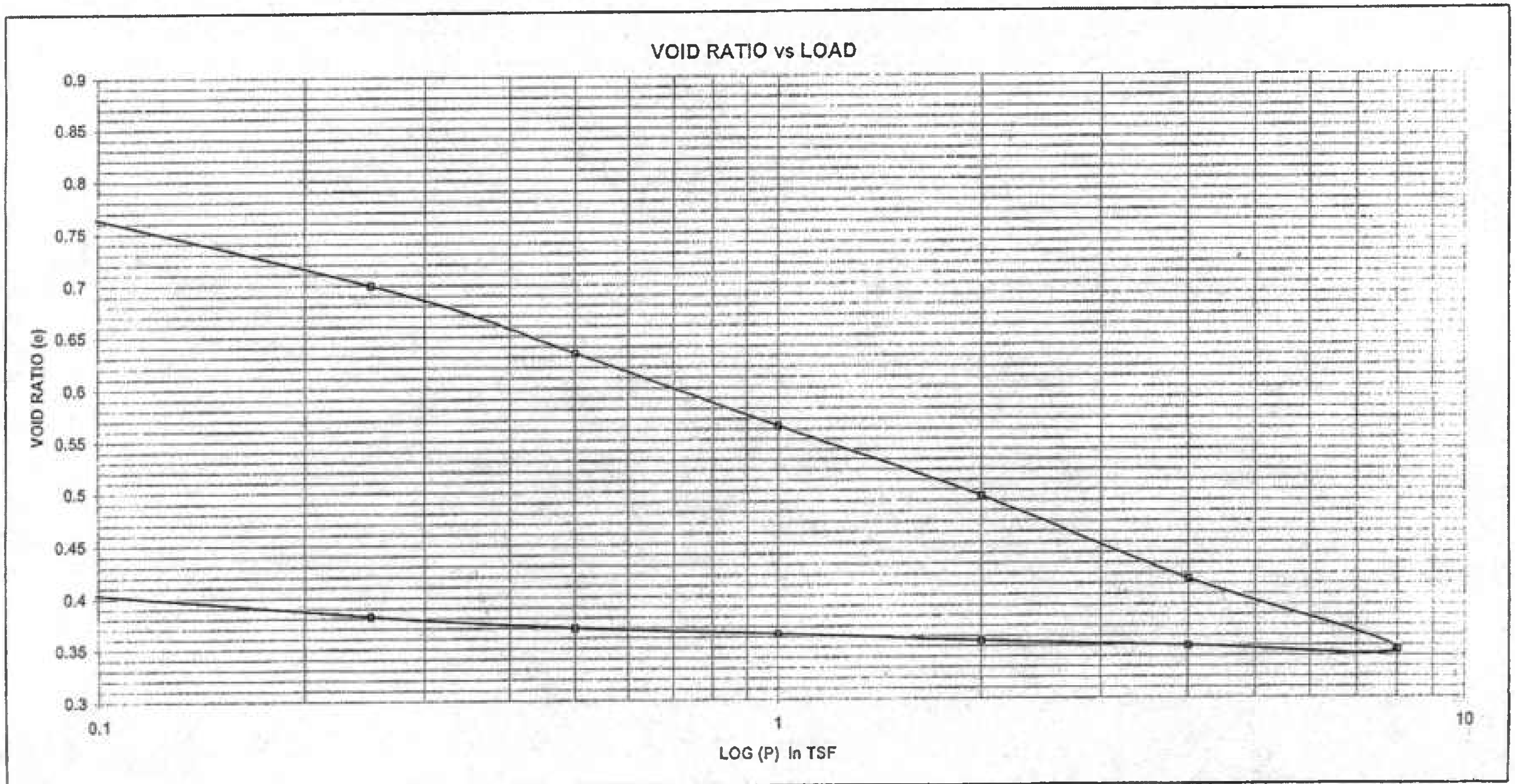
CONSOLIDATION TEST

PROJECT NAME:	James Island					PROJECT NO:	01572-04
SAMPLE NUMBER:	JB-7	DEPTH (FT):	21-23	MOISTURE CONTENT:	31.8 %	LAB NO:	
WET DENSITY (pcf):	114.4	DRY DENSITY (pcf):	86.8	SPECIFIC GRAVITY:	2.67	INITIAL VOID RATIO:	0.92
SOIL DESCRIPTION:	Greenish Gray Sandy Clay						



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CONSOLIDATION TEST

PROJECT NAME: James Island

PROJECT NO: 01572-04

SAMPLE NUMBER: JB-9

DEPTH (FT): 19-21

MOISTURE CONTENT: 45.1 %

LAB NO:

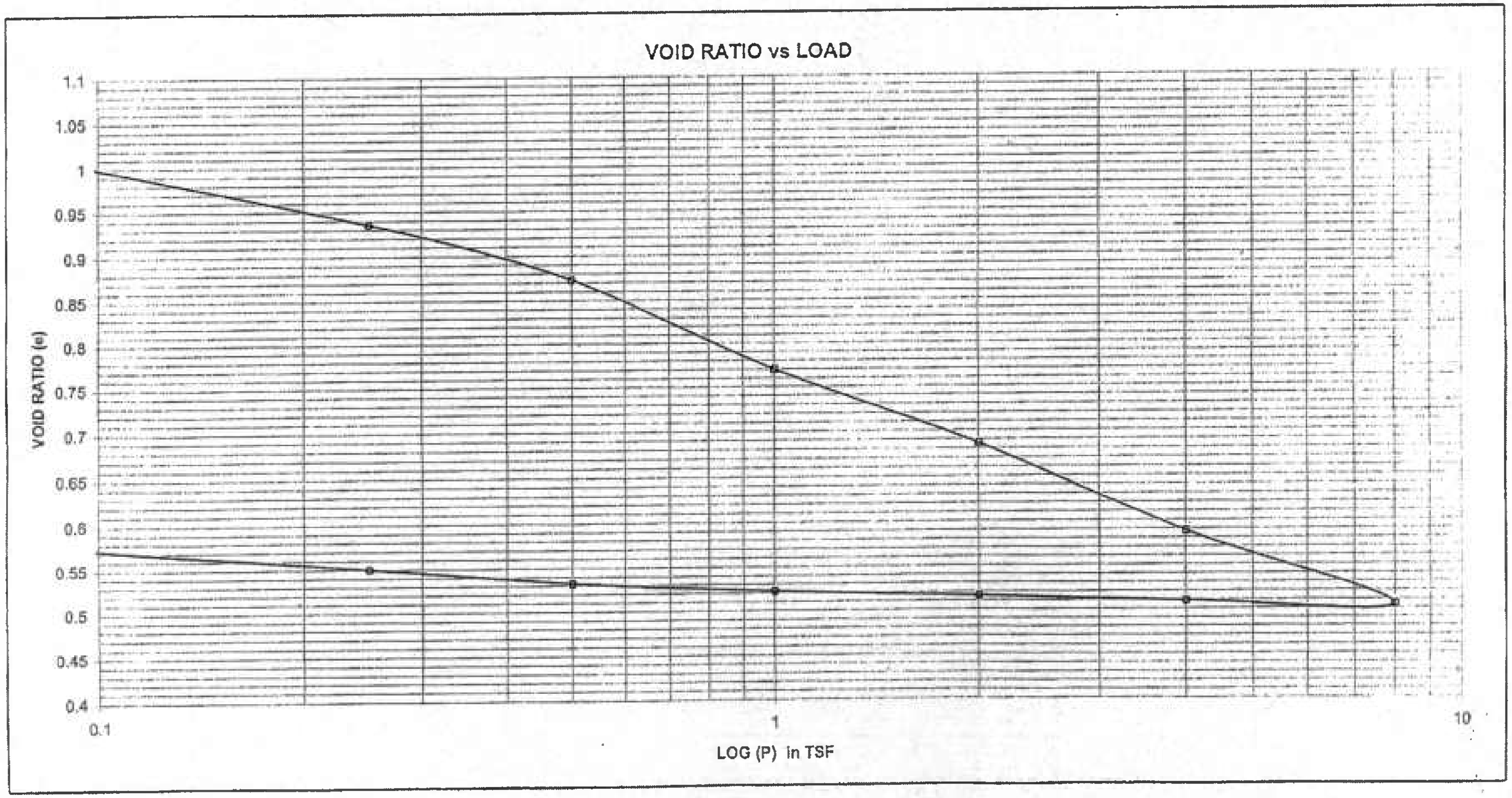
WET DENSITY (pcf): 112.3

DRY DENSITY (pcf): 77.4

SPECIFIC GRAVITY: 2.67

INITIAL VOID RATIO: 1.15

SOIL DESCRIPTION: Greenish Gray Silty Clay



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CONSOLIDATION TEST

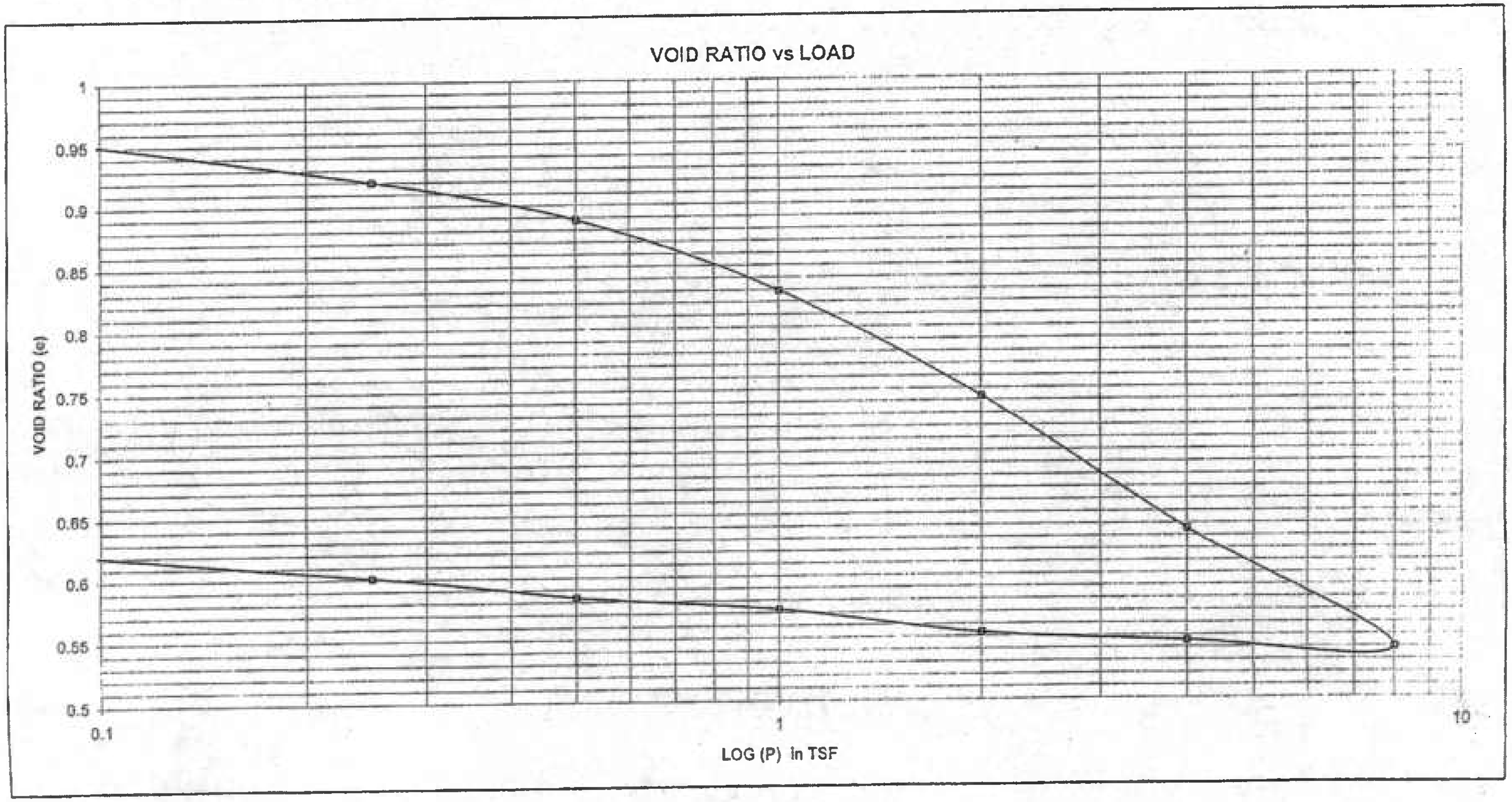
PROJECT NO: 01572-04

PROJECT NAME: James Island

SAMPLE NUMBER: JB-13 DEPTH (FT): 13-15 MOISTURE CONTENT: 36.0 % LAB NO:

WET DENSITY (pcf): 111.9 DRY DENSITY (pcf): 82.3 SPECIFIC GRAVITY: 2.67 INITIAL VOID RATIO: 1.03

SOIL DESCRIPTION: Greenish Gray Silty Clay



CONSOLIDATION TEST

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PROJECT NAME: James Island

PROJECT NO: 01572-04

SAMPLE NUMBER: JB-20

DEPTH (FT): 31-33

MOISTURE CONTENT: 39.6 %

LAB NO:

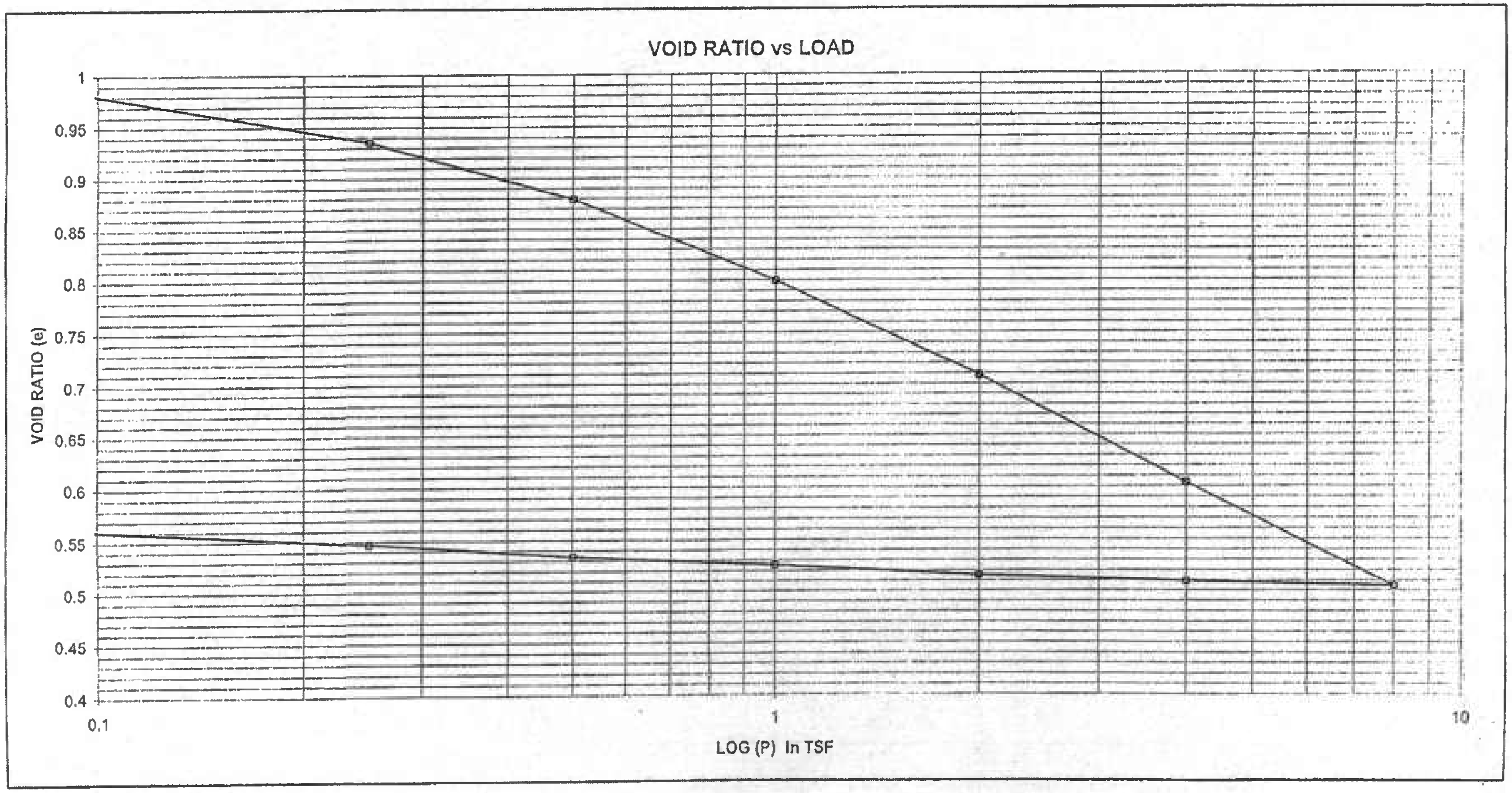
WET DENSITY (pcf): 111.2

DRY DENSITY (pcf): 79.6

SPECIFIC GRAVITY: 2.67

INITIAL VOID RATIO: 1.09

SOIL DESCRIPTION: Greenish Gray Silty Clay



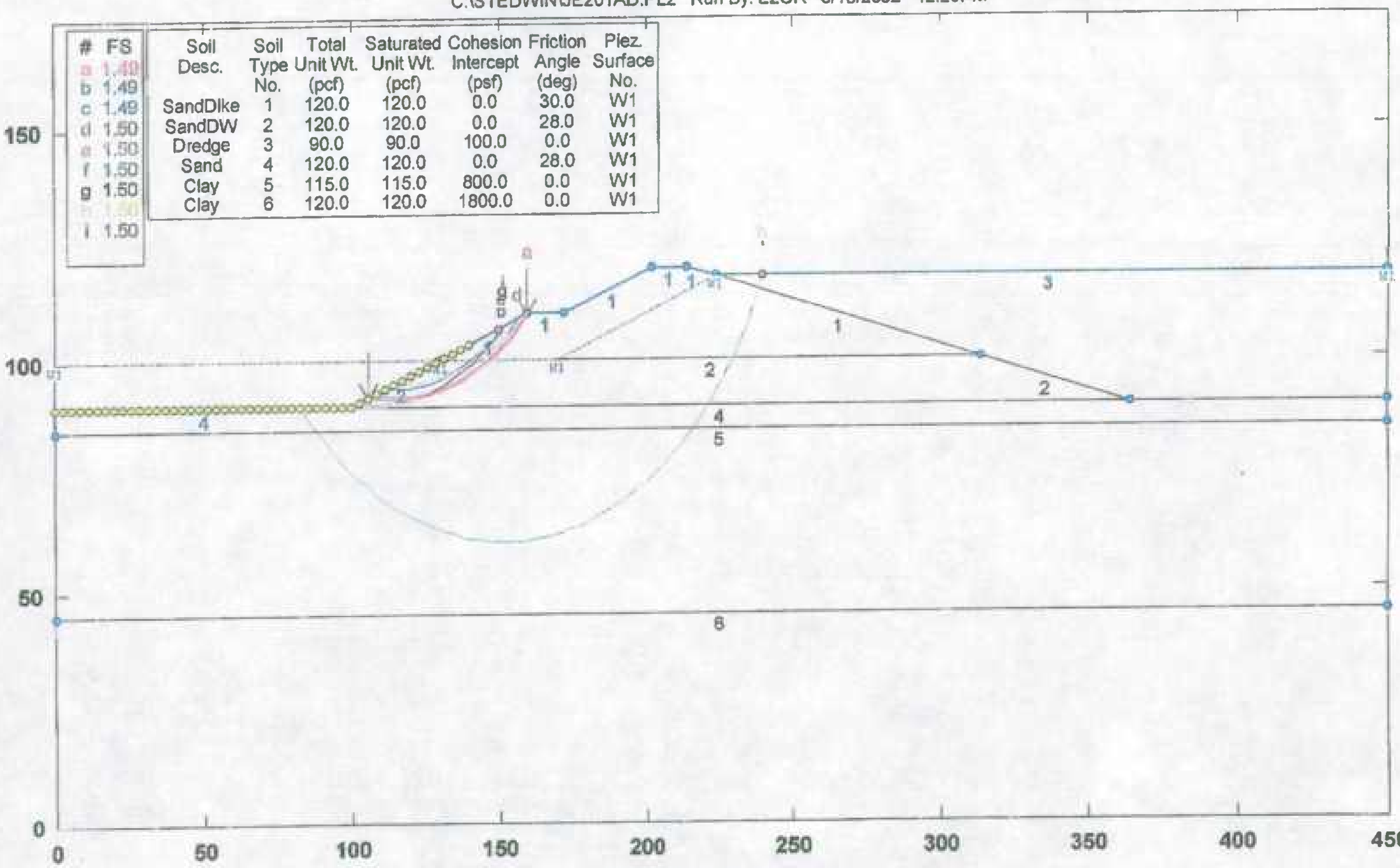
Appendix F
Slope Stability Analysis

Case 1

Case 1A

James Island Exterior Dike (20ft) : Case 1A :Dike

C:\STEDWIN\JE201AD.PL2 Run By: E2CR 3/15/2002 12:29PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

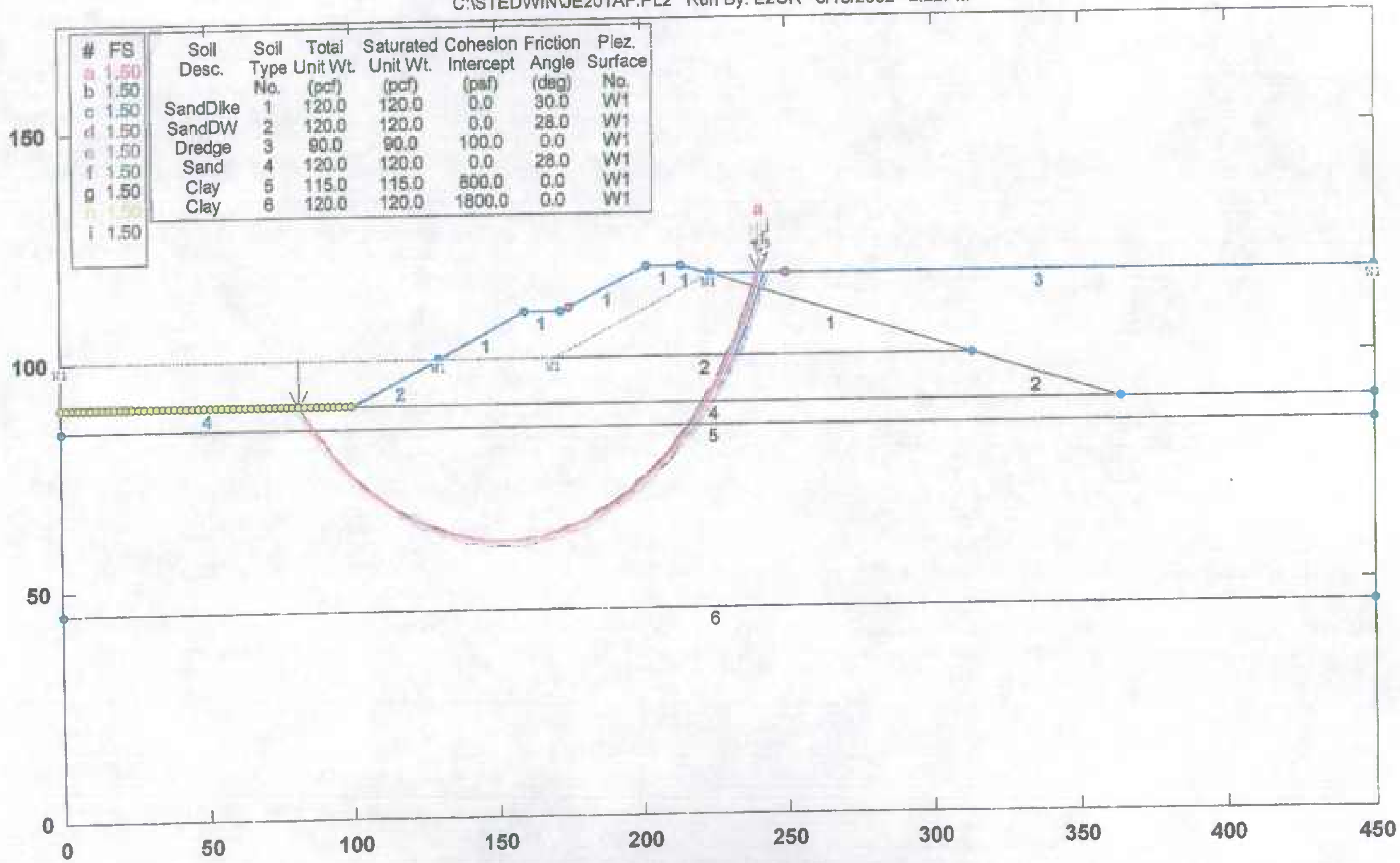
STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (20ft):Case 1A :Foundation

C:\STEDWIN\JE201AF.PL2 Run By: E2CR 3/15/2002 2:22PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

STABL6H FSmin=1.50

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (20ft) : Case 1A :Block

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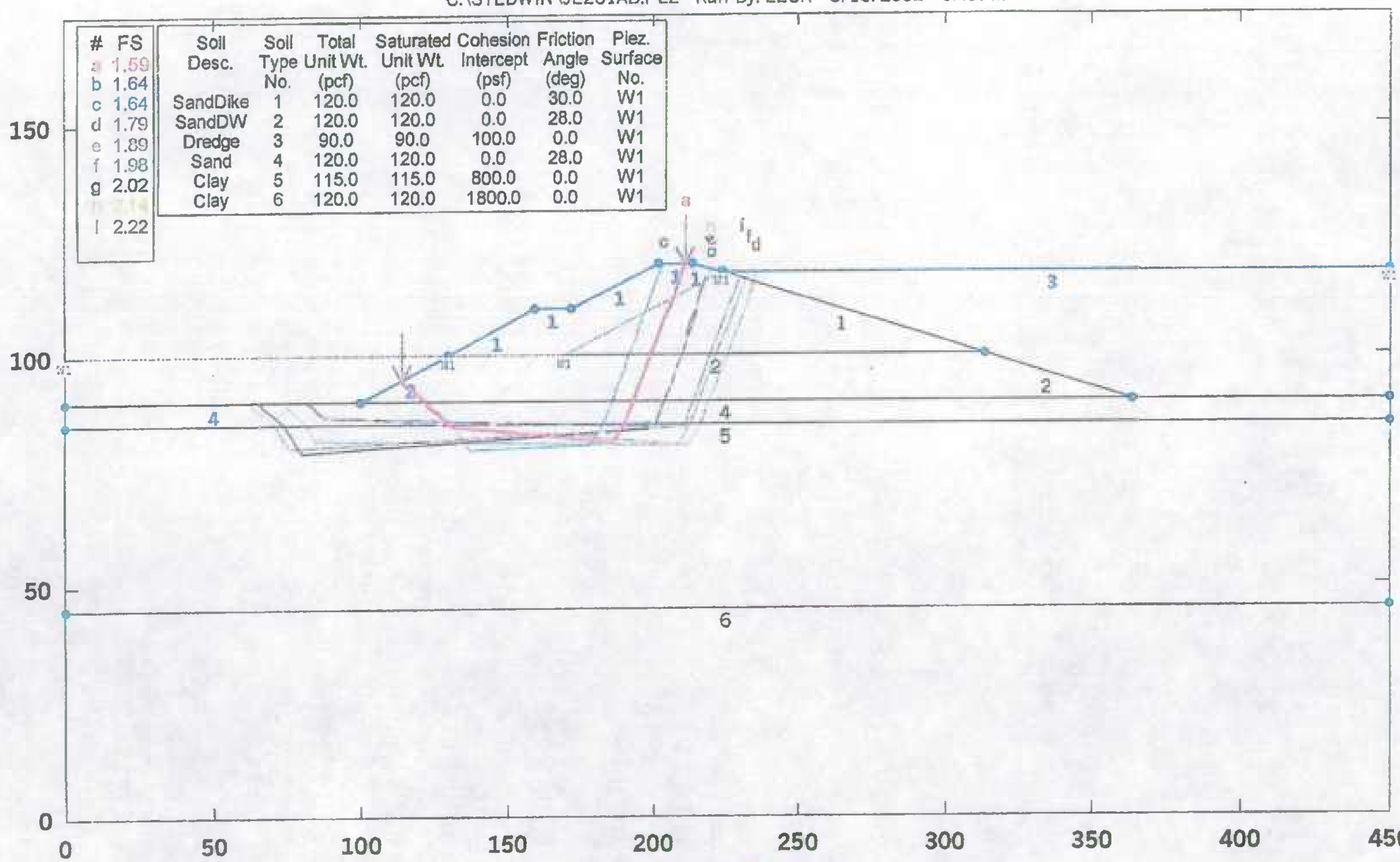

STABL6H FSmin=1.59

Safety Factors Are Calculated By The Modified Janbu Method

STED

James Island Exterior Dike (10ft) : Case 1 A: Dike

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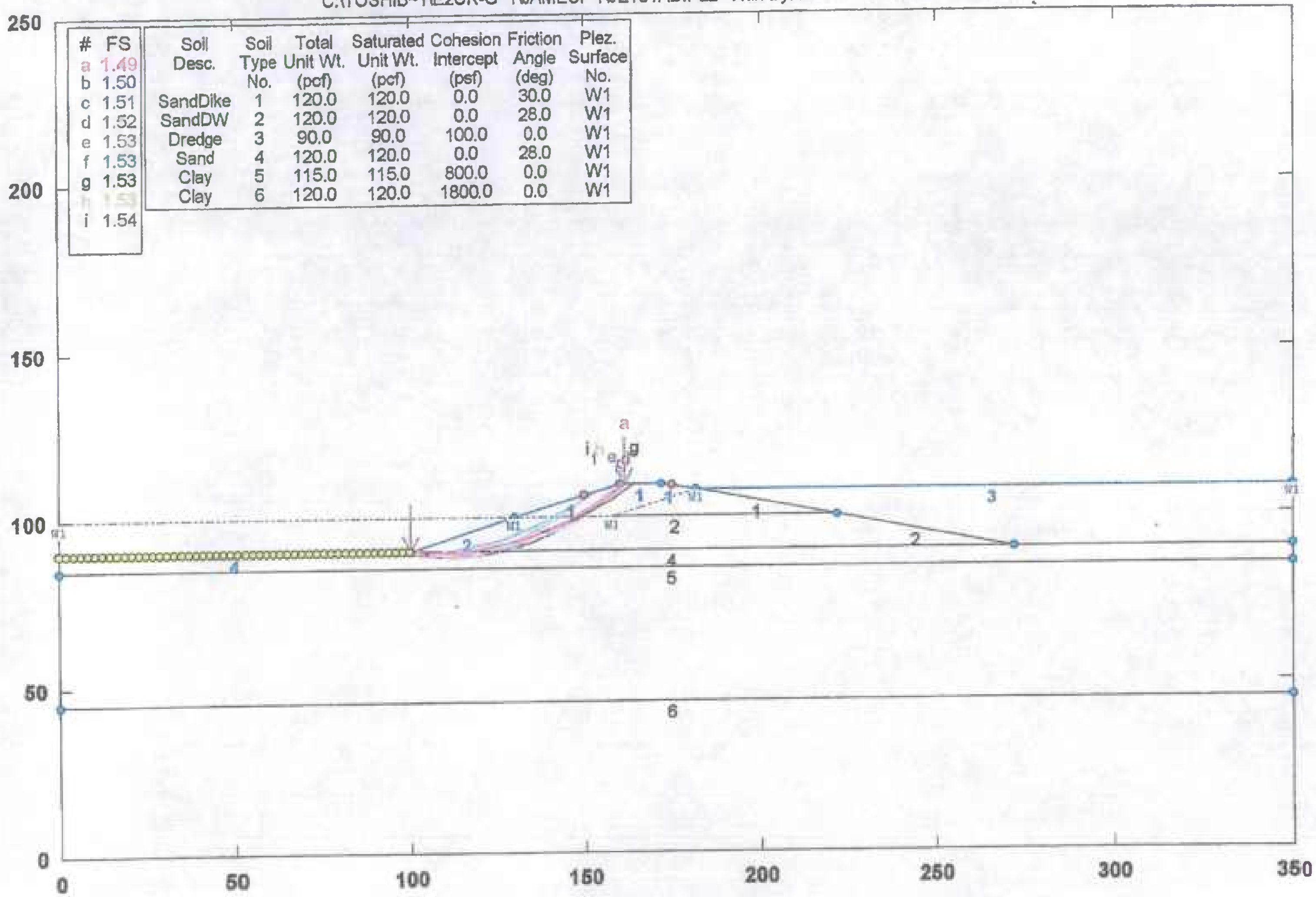


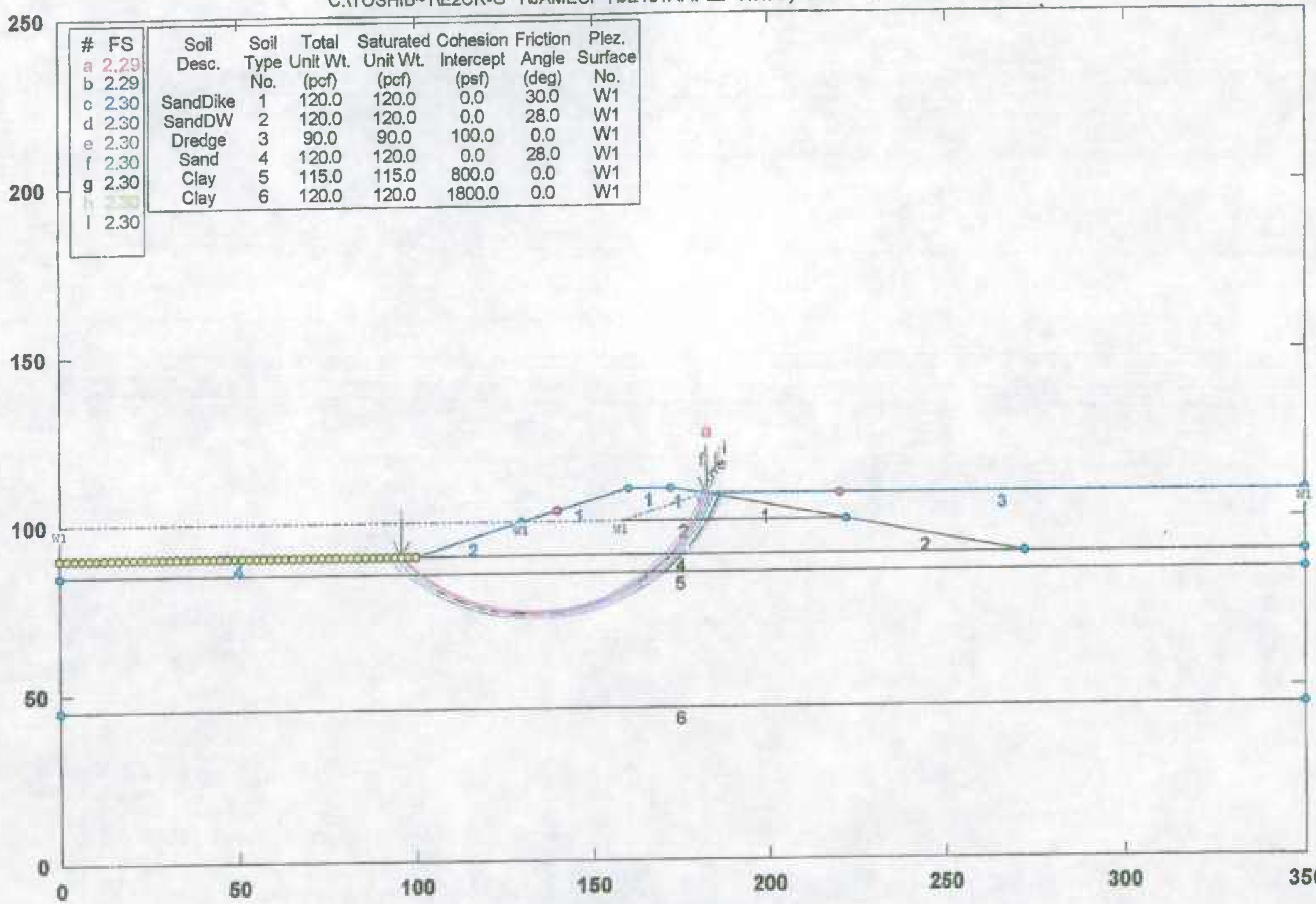
STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (10ft) :Case 1A:Foundation

C:\TOSHIB~1\E2CR-G~1\JAMESI~1\JE101AF.PL2 Run By: E2CR 3/15/2002 11:09AM



STABL6H FSmin=2.29

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (10ft) : Case 1A:Block

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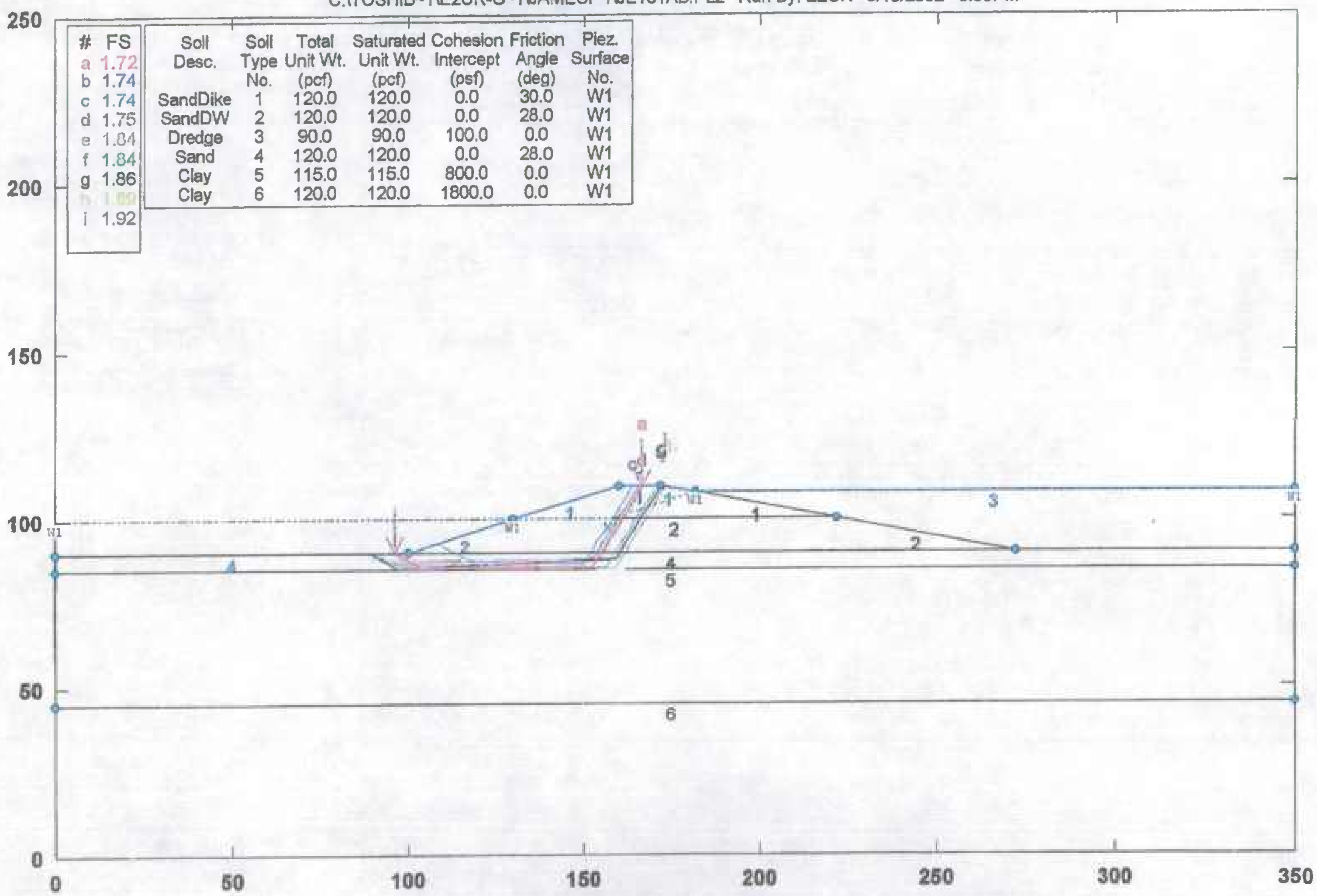

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

STABL6H FSmin=1.72
Safety Factors Are Calculated By The Modified Janbu Method

STED

Case 1B

James Island Exterior Dike (20ft) : Case 1B :Dike

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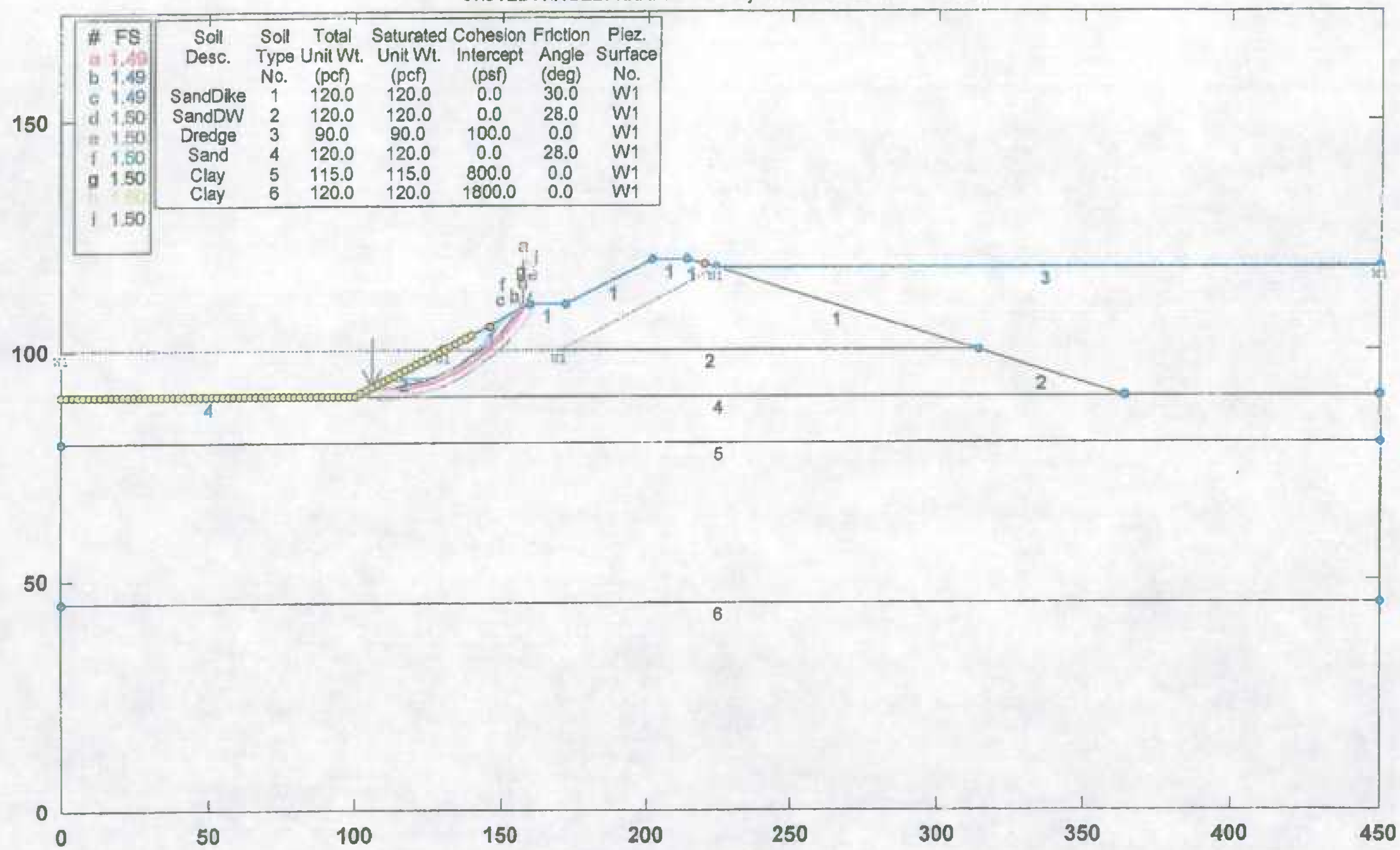

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (20ft):Case 1B :Foundation

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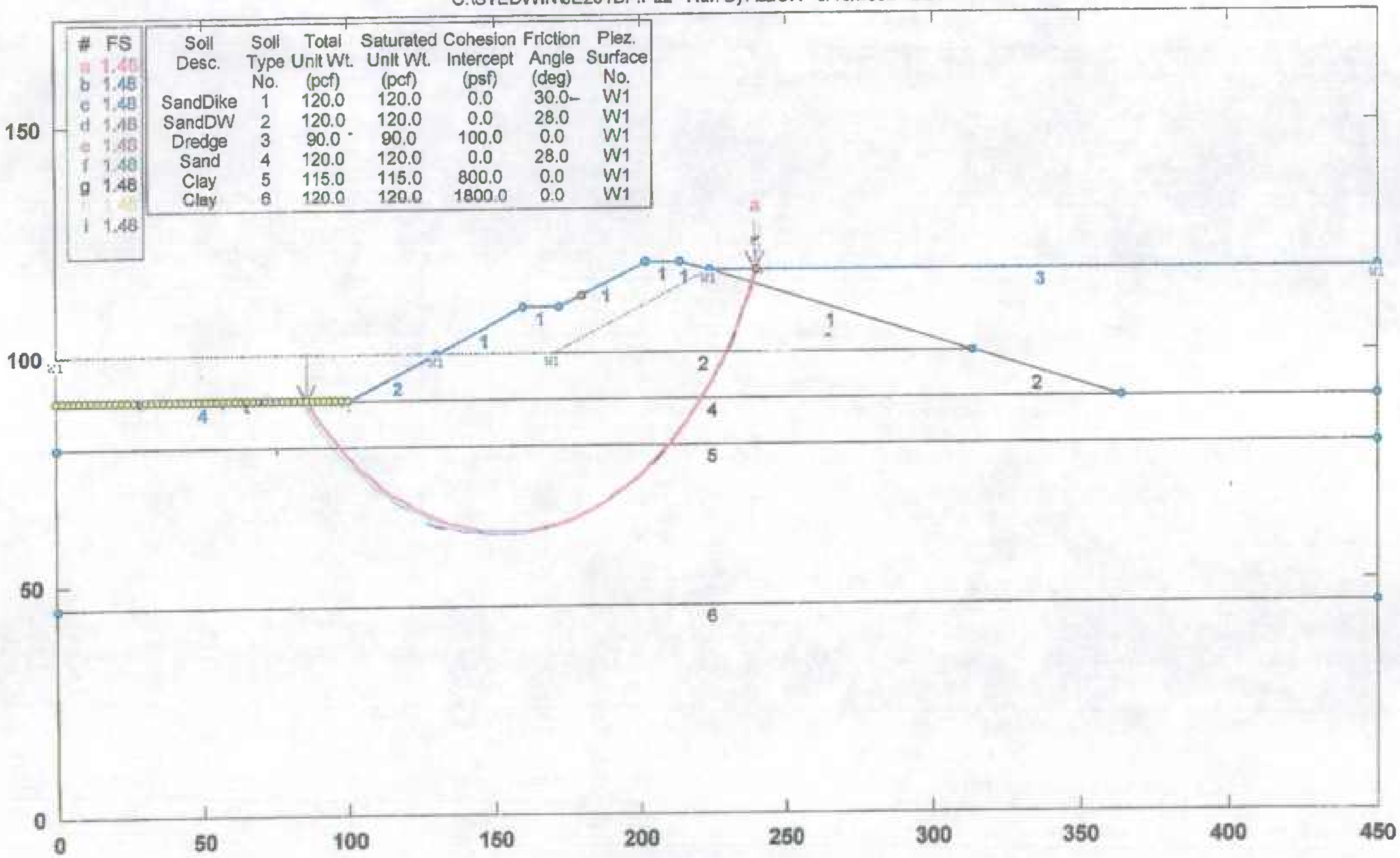

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

STABL6H FSmin=1.48

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (20ft) : Case 1B :Block

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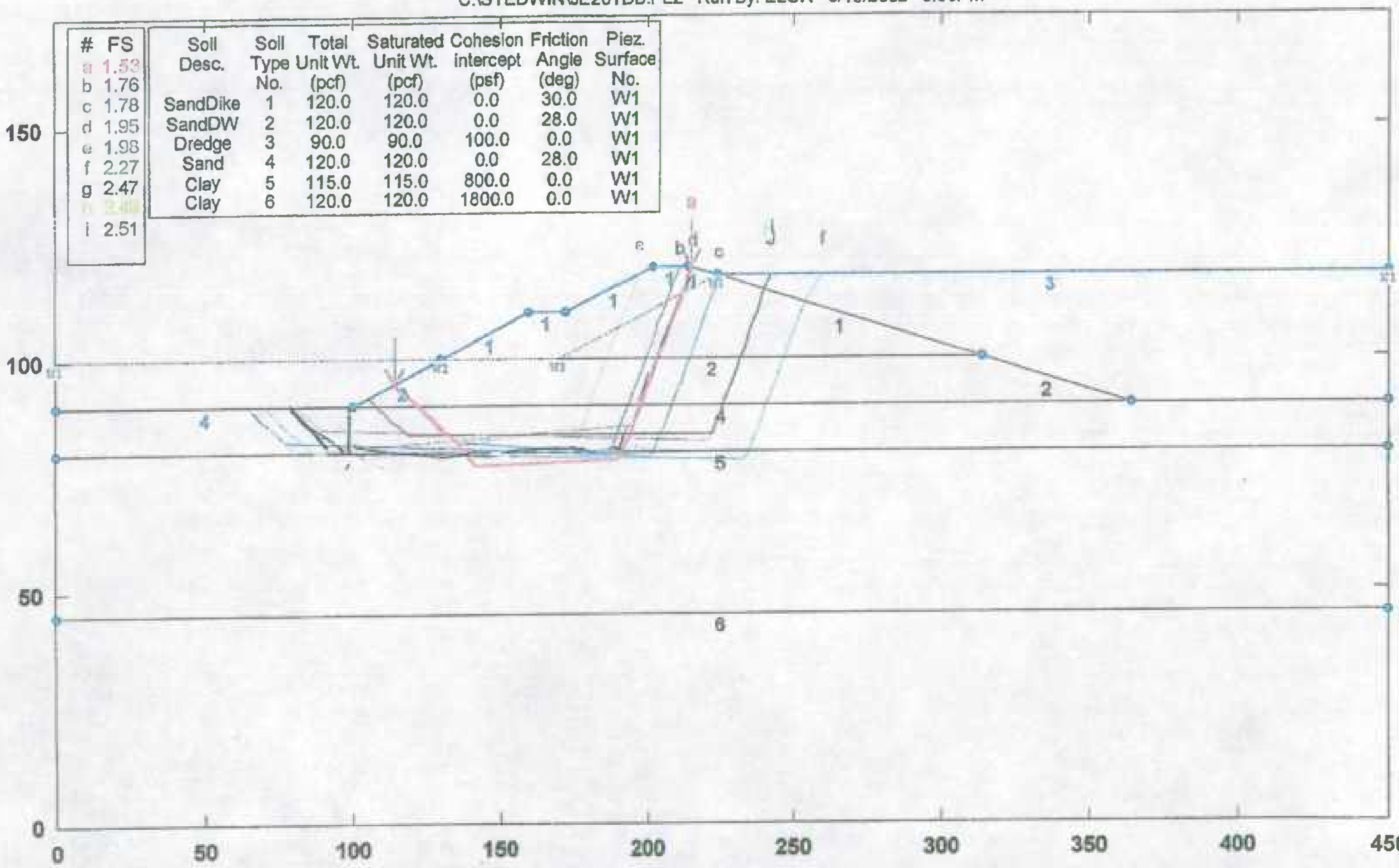


Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

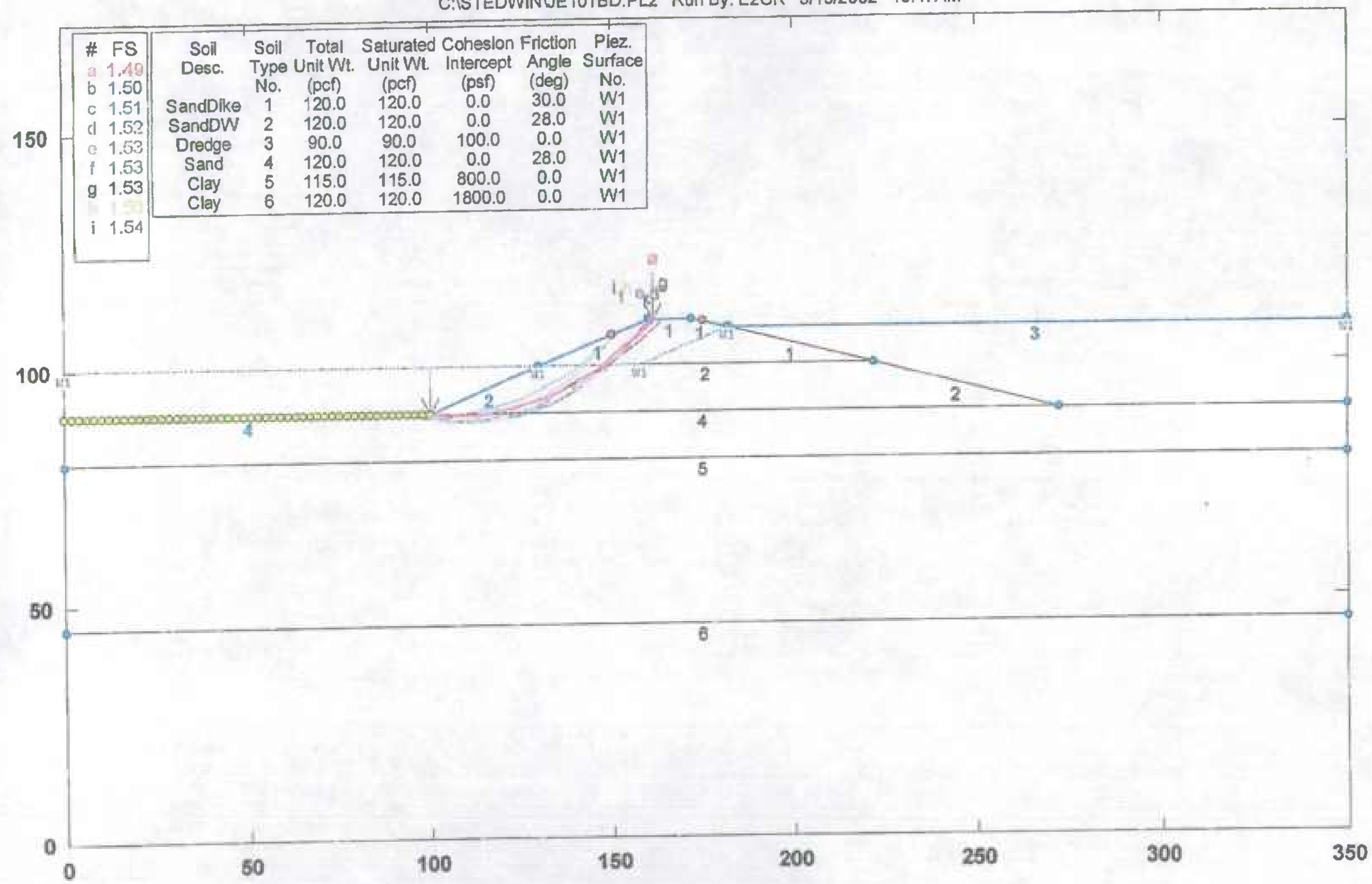
PCSTABL5M/si FSmin=1.53

Safety Factors Are Calculated By The Modified Janbu Method

STED

James Island Exterior Dike (10ft) : Case 1 B: Dike

C:\STEDWIN\JE101BD.PL2 Run By: E2CR 3/15/2002 10:47AM



#	FS
a	1.49
b	1.50
c	1.51
d	1.52
e	1.53
f	1.53
g	1.53
h	[illegible]
i	1.54

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

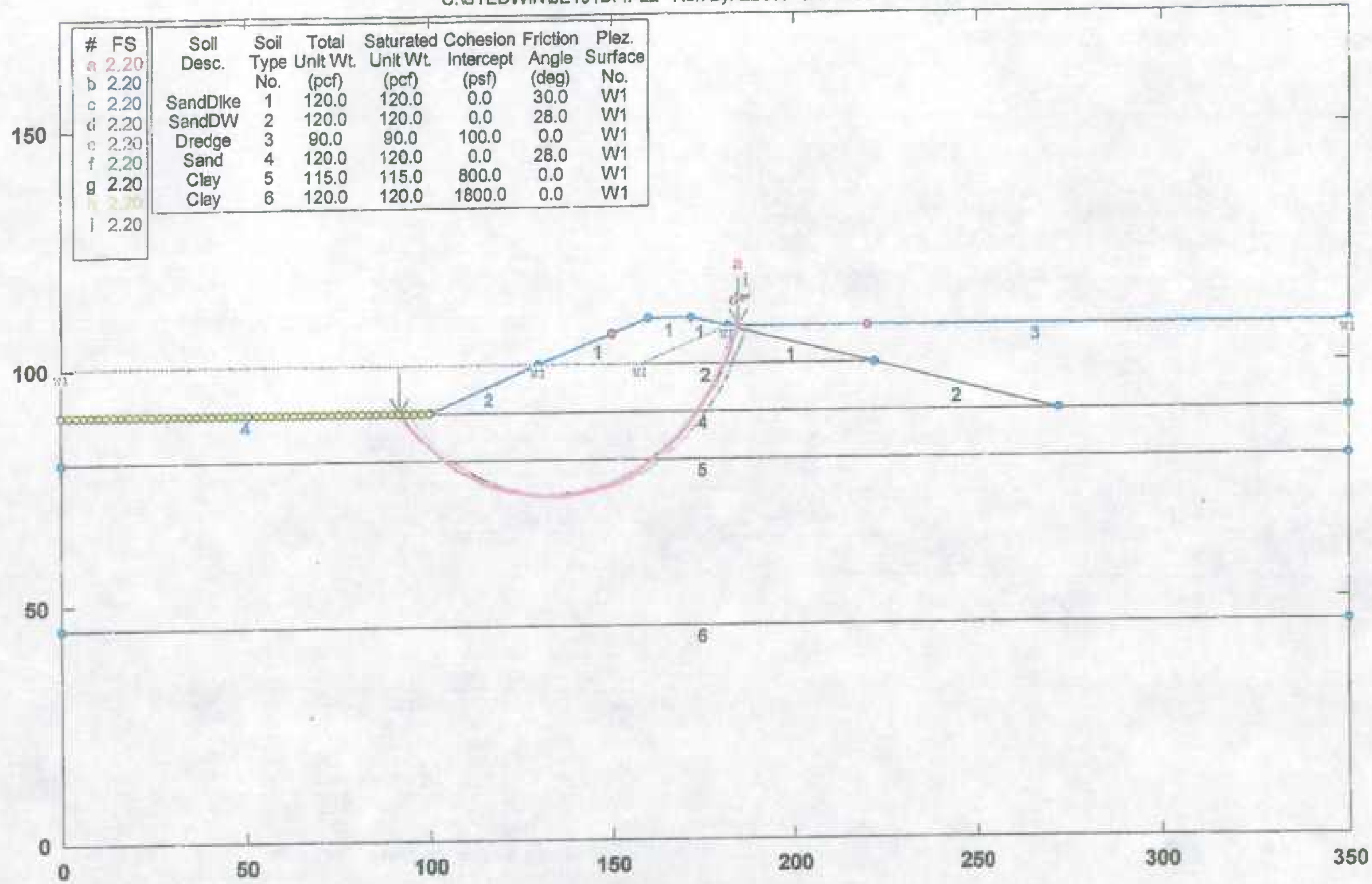
STED

James Island Exterior Dike (10ft) :Case1B:Foundation

C:\STEDWIN\JE101BF.PL2 Run By: E2CR 3/15/2002 11:25AM

#	FS
a	2.20
b	2.20
c	2.20
d	2.20
e	2.20
f	2.20
g	2.20
h	2.20
i	2.20

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1



STABL6H FSmin=2.20

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (10ft) : Case 1 B: Block

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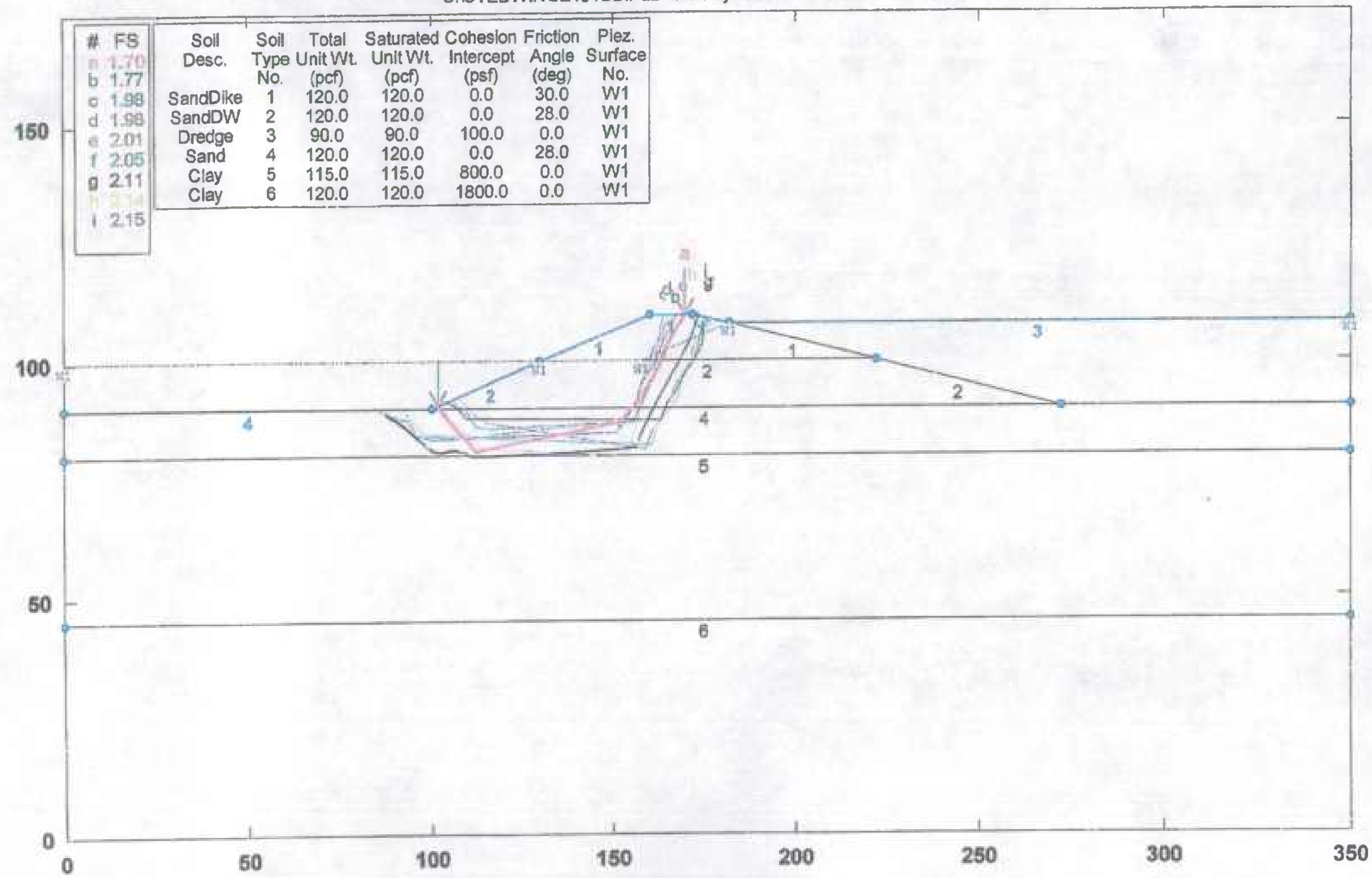

#	FS
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b	1.77
c	1.98
d	1.98
e	2.01
f	2.05
g	2.11
h	2.14
i	2.15

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Clay	5	115.0	115.0	800.0	0.0	W1
Clay	6	120.0	120.0	1800.0	0.0	W1

STABL6H FSmin=1.70

Safety Factors Are Calculated By The Modified Janbu Method

STED

Case 2

James Island Exterior Dike (20ft) : Case 2 :Dike

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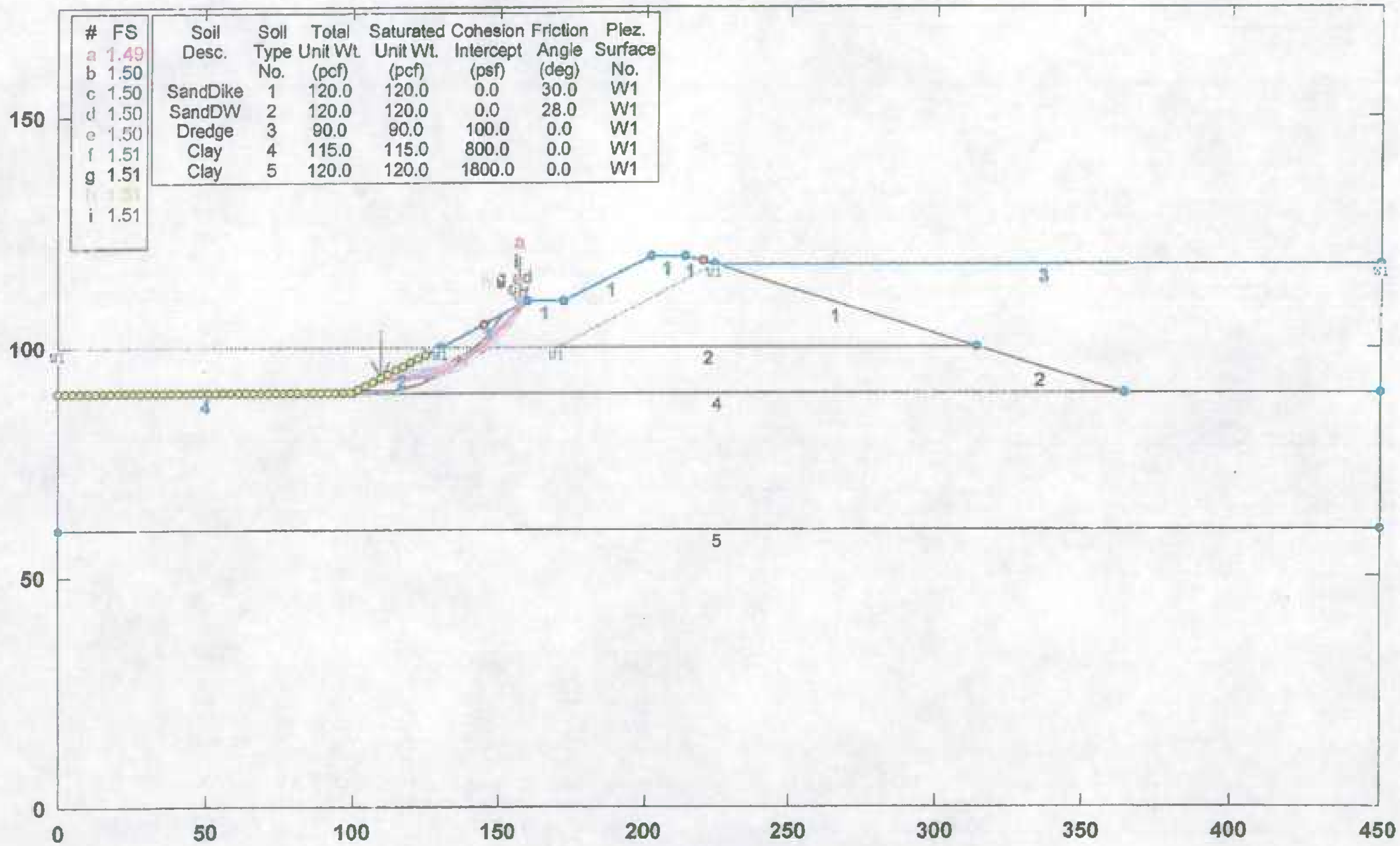

STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (20ft) :Case 2 :Foundation

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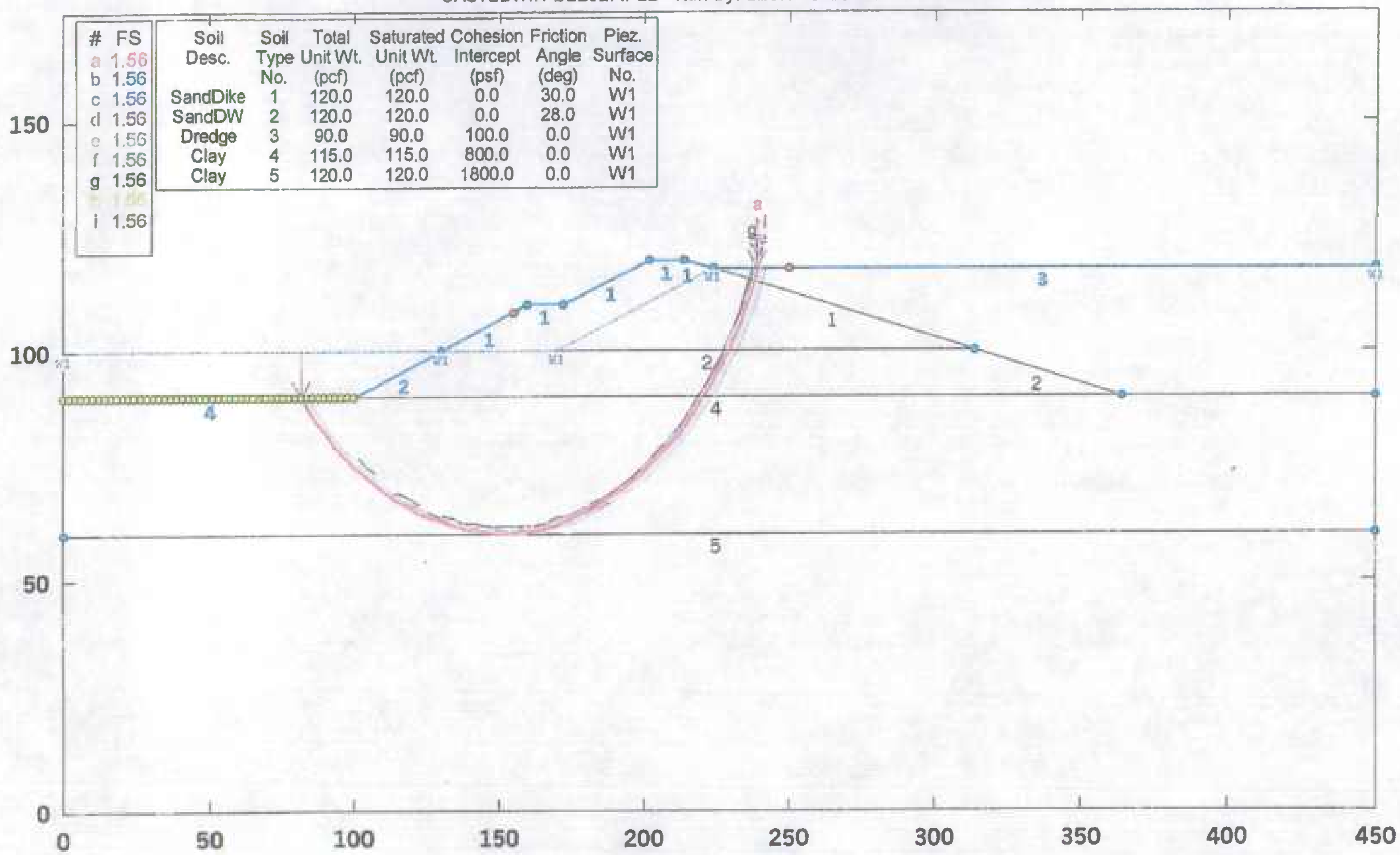

STABL6H FSmin=1.56

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (10ft) : Case 2: Dike

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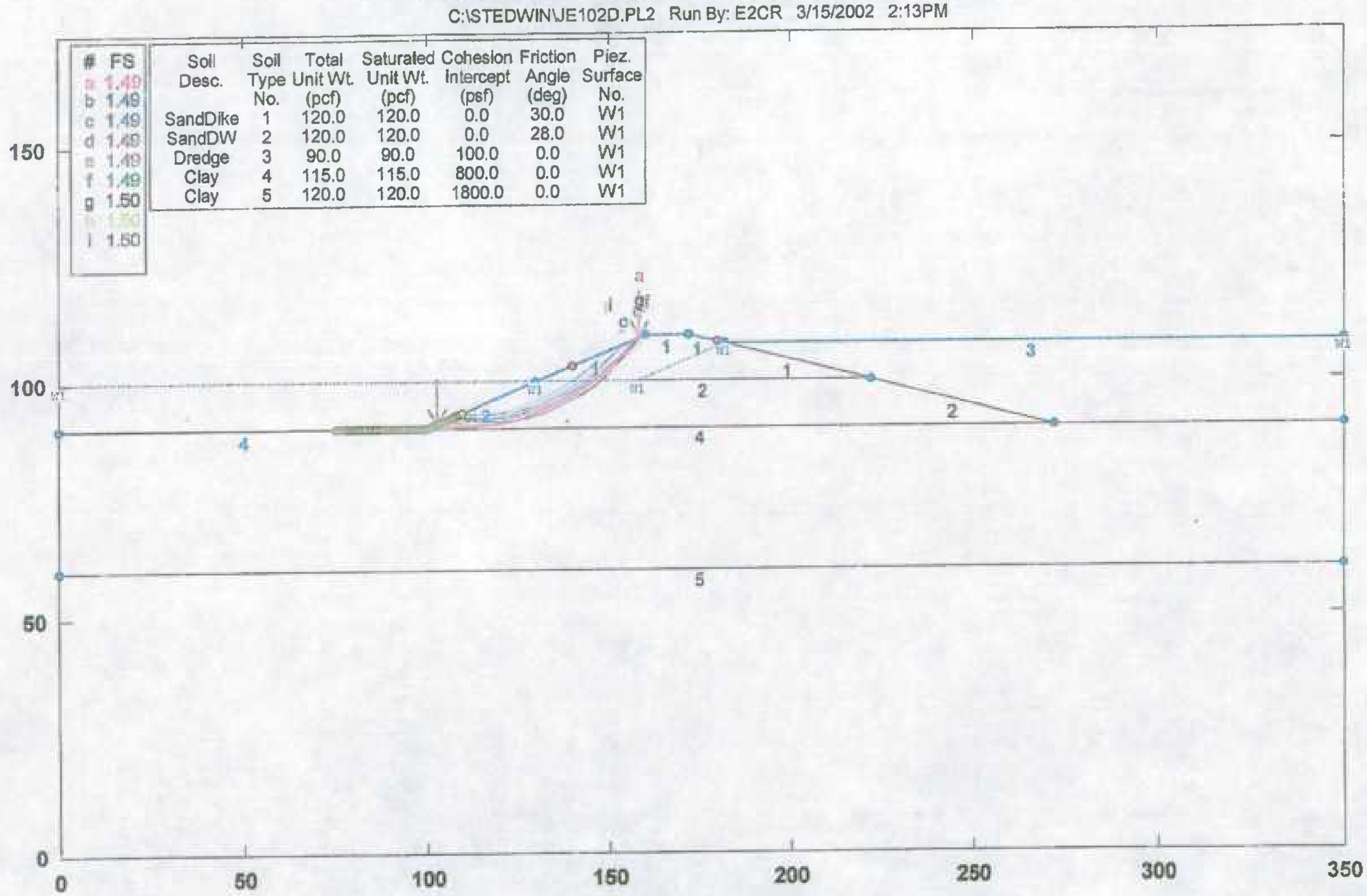

STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (10ft) : Case 2:Foundation

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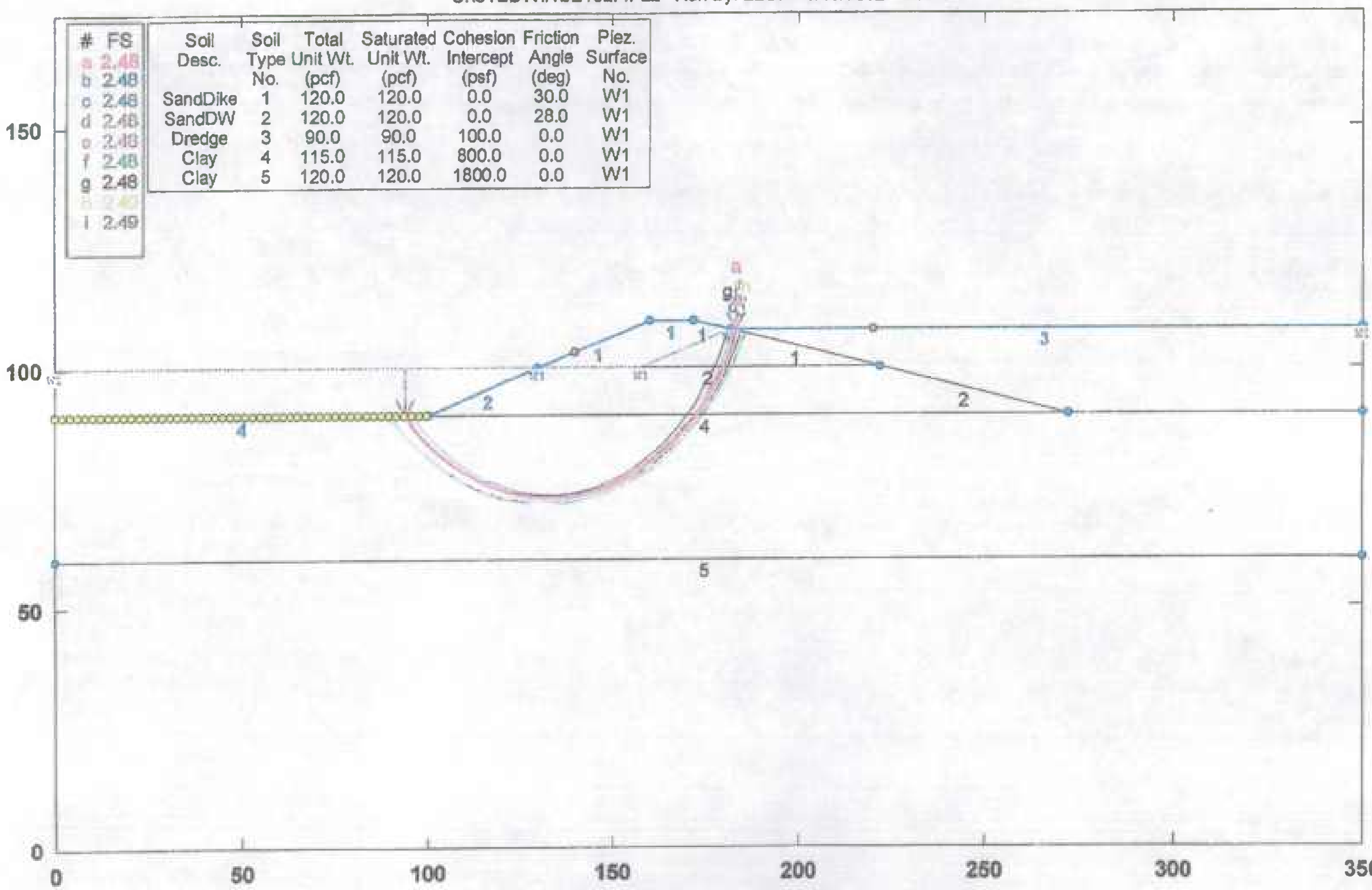

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Clay	4	115.0	115.0	800.0	0.0	W1
Clay	5	120.0	120.0	1800.0	0.0	W1

STABL6H FSmin=2.48

Safety Factors Are Calculated By The Modified Bishop Method

STED

Case 3

James Island Exterior Dike (20ft) : Case 3 :Dike

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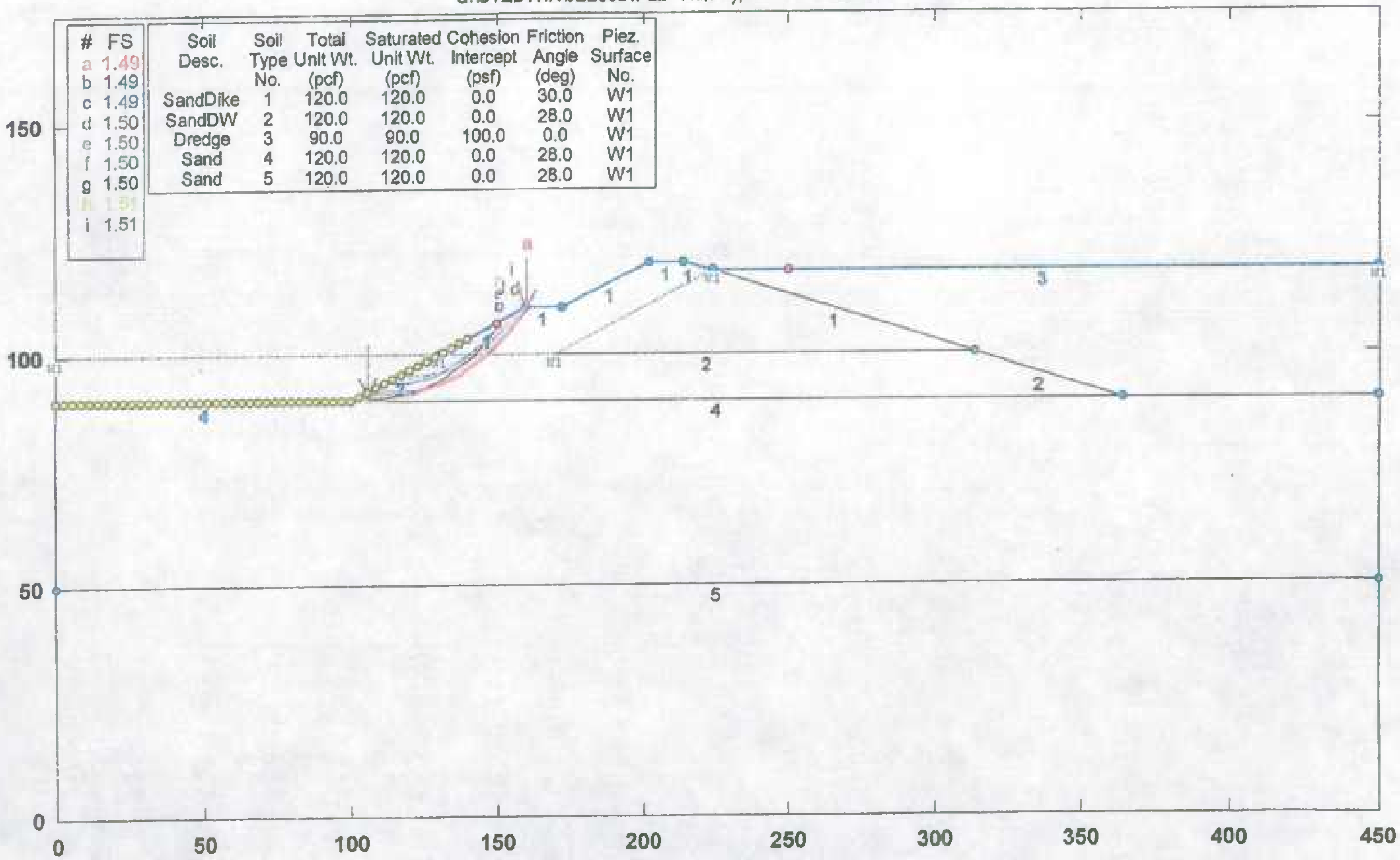

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Sand	5	120.0	120.0	0.0	28.0	W1

STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (20ft) :Case 3 :Foundation

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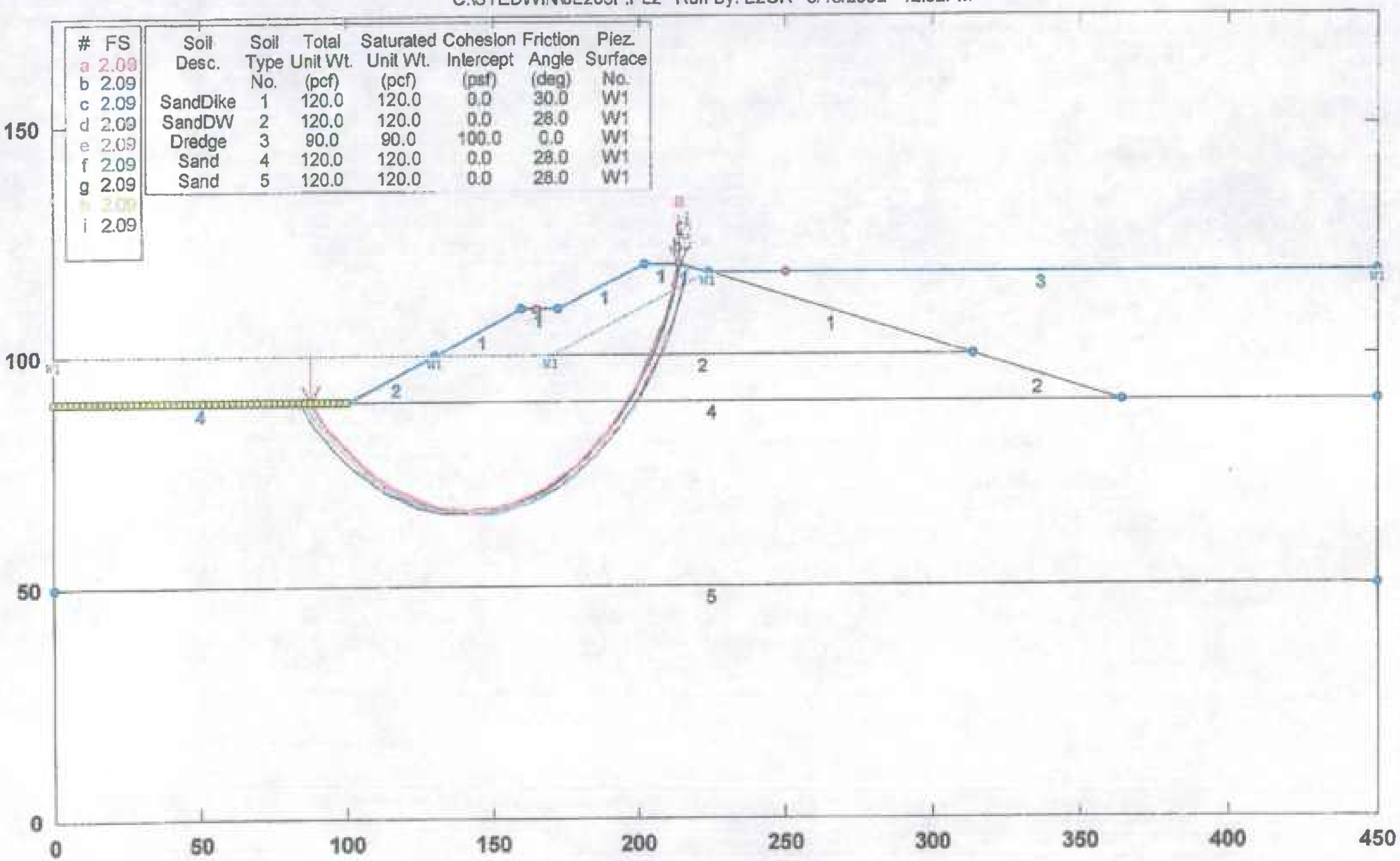

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
SandDike	1	120.0	120.0	0.0	30.0	W1
SandDW	2	120.0	120.0	0.0	28.0	W1
Dredge	3	90.0	90.0	100.0	0.0	W1
Sand	4	120.0	120.0	0.0	28.0	W1
Sand	5	120.0	120.0	0.0	28.0	W1

STABL6H FSmin=2.09

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (10ft) : Case 3: Dike

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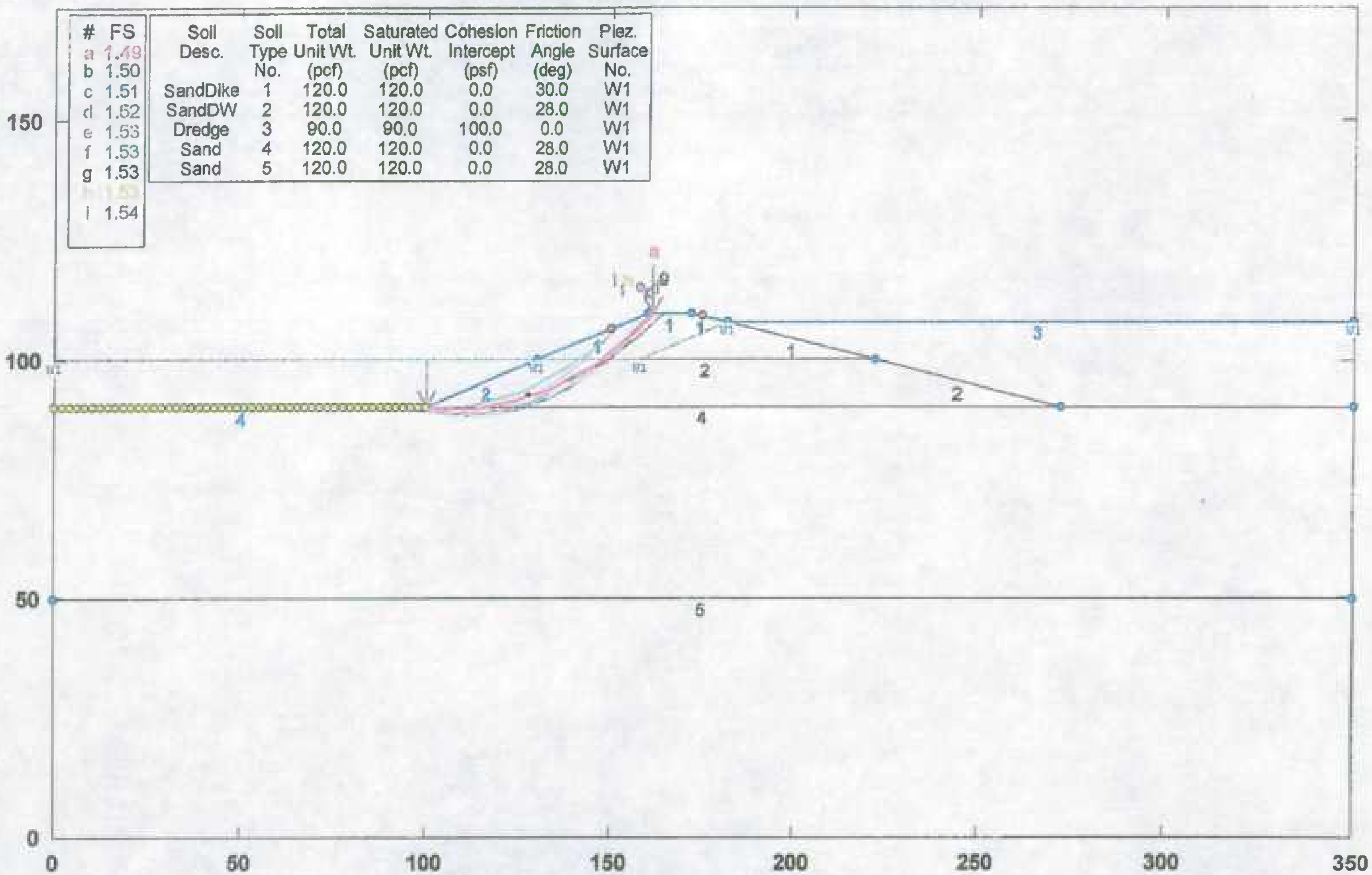

STABL6H FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

STED

James Island Exterior Dike (10ft) :Case 3:Foundation

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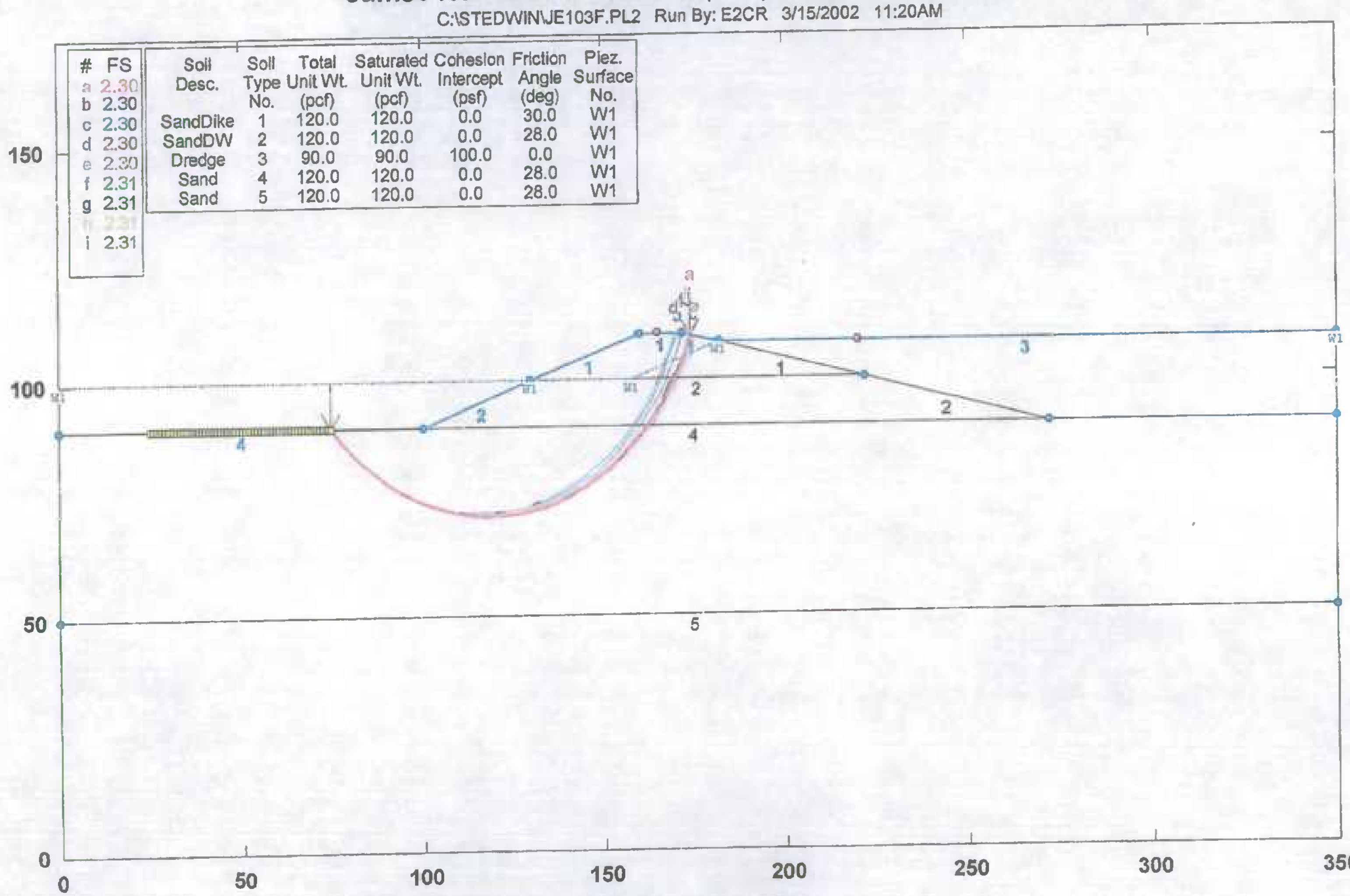


STABL6H FSmin=2.30

Safety Factors Are Calculated By The Modified Bishop Method

STED

APPENDIX B

Appendix B:

Coastal Engineering Investigation

(Moffatt and Nichol Engineers)

James Island
Coastal Engineering Investigation
Reconnaissance Study

Maryland Port Administration
MPA Contract Number: 500912
MPA Pin Number: 600105-P

Maryland Environmental Services
MES Contract Number: 02-07-47

Final Report

Prepared by

Moffatt & Nichol Engineers
2700 Lighthouse Point East
Suite 501
Baltimore, MD 21224

August 30, 2002

EXECUTIVE SUMMARY

This Coastal Engineering Investigation report provides information on the James Island site being considered as a beneficial use of dredged material project. This report addresses two major elements:

- Evaluation of existing available data pertaining to environmental site conditions and specifically related to coastal engineering aspects of design
- Design of the containment dikes as regards armor protection and structure height

ENVIRONMENTAL SITE CONDITIONS

A summary of site conditions relevant to this study is provided below:

- **Bathymetry and Topography.** Water depths in the area where the dikes would be located range from –2 to –12 ft MLLW, with an average depth along the exterior dikes ranging from –3 to –12 ft MLLW.

- **Wind Conditions.** Design winds for the site are developed from data collected at Baltimore-Washington International (BWI) Airport. Design wind speeds are calculated for return periods ranging from 5 to 100 years for eight wind directions, including the direction with the longest fetch (south).

- **Water Levels.** Normal water levels at the site are dictated by astronomical tides. Mean tide level is 0.9 ft above MLLW. Design water levels for the project area are dominated by storm surge, which for a 100-year return period can be as high as 5.6 ft above MLLW.

- **Wave Conditions.** The highest offshore waves for all alignments at the site approach from the north and south directions. Shallow bathymetry in the vicinity of the site require calculation of nearshore wave spectra. Alignments 4 and 5 have relatively larger depths for the southwest direction, thus the largest nearshore waves for these alignments are from the southwest direction. Predicted peak spectral wave period ranges from a minimum of 4.9 seconds for a 5-year storm, to a maximum of 6.4 for a 100-year storm. Significant offshore wave height ranges from 5.4 feet for a 5-year to 10.1 for a 100-year storm.

- **Currents.** Currents in the project area are relatively weak, with a maximum velocity of 1 ft/sec, and are not considered critical to design the shore protection. However, current patterns could be affected by island restoration. The effects of the dike construction will be investigated in the Hydrodynamics and Sedimentation Modeling Report for this study.

- **Site Soil Characteristics.** Results of the preliminary study by E2CR indicate that the underlying soil is silty sand. There are, however, areas with soft silty clays at the mud line which will need to be undercut and backfilled with sand.

COASTAL PROTECTION DIKE DESIGN

Preliminary cross-sections are developed for coastal protection of the containment dikes. Cross-sections varied primarily in accordance with wave exposure and foundation conditions.

General Conditions for Dike Design

- Designs are based on 35-year return period storm conditions
- Armored sections incoporate a 3:1 side slope, non-armored sections have 5:1 side slopes
- Dike heights are based on (1) allowable overtopping for an unarmored crest and (2) an allowance for settlement
- Stone sizes are computed using the Van der Meer method
- Above grade toe protection is used
- Core is constructed using sand
- A crushed stone roadway having a width of 20 ft is located on the structure crest.

Dike Sections

Dike Section 1 has a crest of +11.5 ft MLLW, and includes two layers of 5000 pound armor stone, two layers of 500 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 1 also has toe protection consisting of two layers or 2500 pound stone over quarry run stone and geotextile.

Dike Section 2 has a crest of +11.0 ft MLLW, and includes two layers of 4000 pound armor stone, two layers of 400 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 2 also has toe protection consisting of two layers or 2000 pound stone over quarry run stone and geotextile.

Dike Section 3 has a crest of +10.5 ft MLLW, and includes two layers of 3000 pound armor stone, two layers of 300 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 3 also has toe protection consisting of two layers or 1500 pound stone over quarry run stone and geotextile.

Dike Section 4 has a crest of +9.5 ft MLLW, and includes two layers of 2500 pound armor stone, two layers of 250 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 4 also has toe protection consisting of two layers or 1300 pound stone over quarry run stone and geotextile.

Dike Section 5 has a crest of +9.0 ft MLLW, and includes two layers of 2000 pound armor stone, two layers of 200 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 5 also has toe protection consisting of two layers or 1000 pound stone over quarry run stone and geotextile.

Dike Section 6 has a crest of +7.0 ft MLLW, and includes two layers of 700 pound armor stone, two layers of 70 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 6 also has toe protection consisting of two layers or 350 pound stone over quarry run stone and geotextile.

Dike Section 7 for James Island differs significantly from Sections 1 to 6. Dike Section 7 is constructed entirely of sand and has a crest of +7.0 ft MLLW and 5:1 side slopes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Note: Figures are included at the end of their respective chapter

1. INTRODUCTION

1.1 Purpose and Objectives

The purpose of this Coastal Engineering Investigation report is to present a preliminary coastal engineering analysis of five options for beneficial use of dredged material at James Island, located within the Chesapeake Bay at the mouth of the Little Choptank River (Figure 1-1). This preliminary assessment includes a literature search of coastal data and a review of environmental, geotechnical and dredging engineering studies conducted for the site.

The objectives of this study include:

- Analysis of site bathymetry, water levels and wind conditions
- Hindcasting of offshore and nearshore waves at the project site
- Determination of dike design parameters

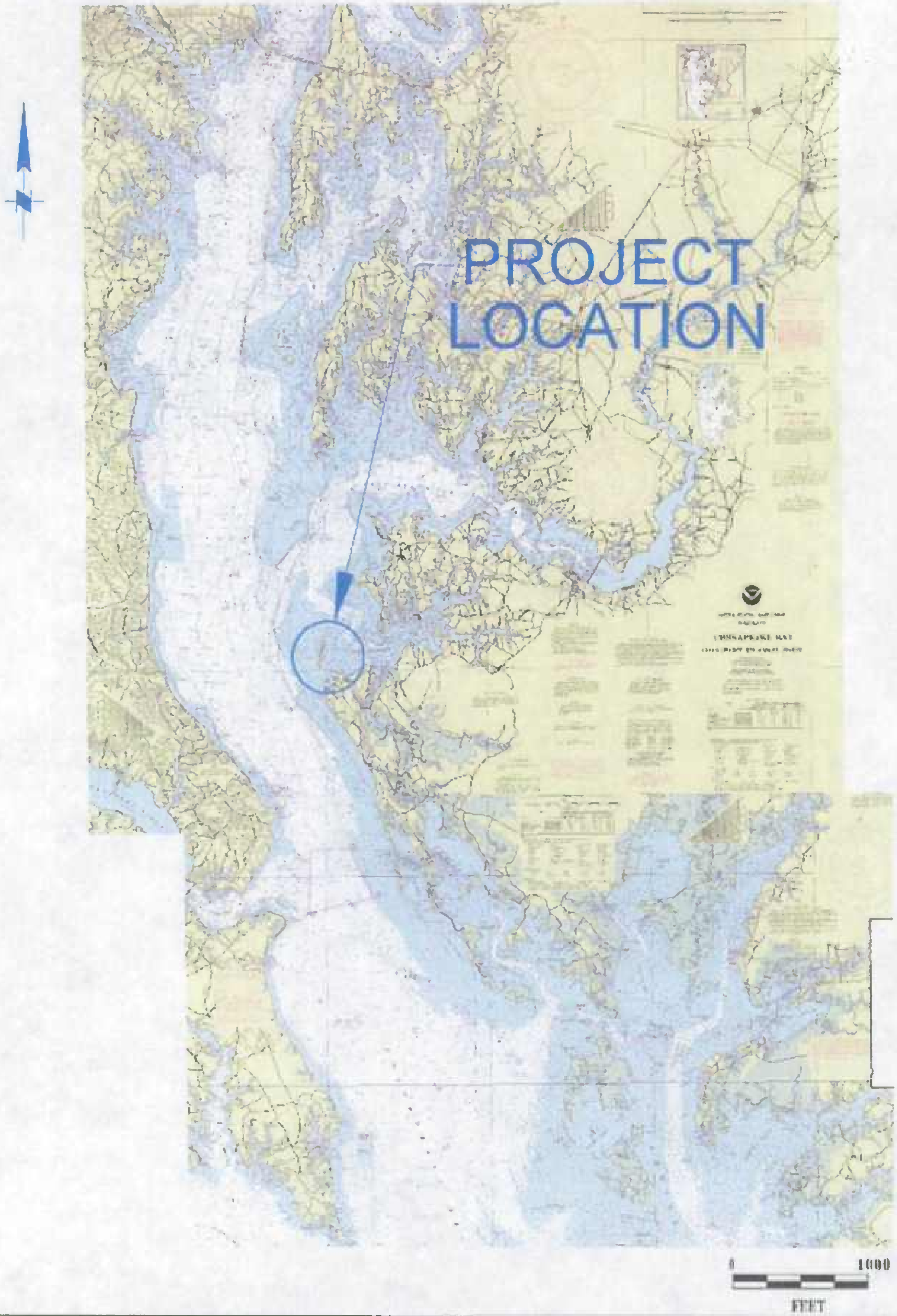
1.2 Project Scope

The scope of this project consists of preparing preliminary reconnaissance studies on the potential for James Island to be used as a site for beneficial use of dredged material. This study includes use of available data on bathymetry, water levels, and wind conditions to hindcast waves for the site. Wave conditions are used to prepare the conceptual design for dikes that would be used to contain dredged material. The design parameters evaluated for this study include: alignment location, crest height, structure slope and armor stone size.

1.3 Project Description

This project provides information as to the feasibility of the concepts developed for James Island for beneficial use of dredged material and whether further evaluation of any of the concepts is warranted. Included in this report are relevant bathymetric, wind, water level and geotechnical data for evaluation of wave height and dike construction requirements.

Waves are hindcast based upon wind data and results from previous studies of storm-induced water levels in the Chesapeake Bay. Offshore and nearshore waves are hindcast for the appropriate winds along the proposed dike alignments. Based upon the hindcast waves, the dike crest heights and armor stone sizes are designed. This report presents the proposed dike alignments and typical cross-sections.



MOFFATT & NICHOL ENGINEERS BALTIMORE, MARYLAND

JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 1-1
PROJECT
LOCATION

2. SITE CONDITIONS

2.1 General

James Island is being studied as a potential site for beneficial use of dredged material. The site is located in the Chesapeake Bay, at the mouth of the Little Choptank River. James Island is located in Dorchester County, at approximately 38° 31' N latitude and 76° 20' W latitude (Maryland State Plane Coordinates N 310,000 E 1,503,000) as shown in Figure 1-1.

Site conditions germane to project design include bathymetry and topography, wind conditions, water levels, wave conditions, tidal currents, and site soil characteristics. A discussion of each of these factors is presented in the following paragraphs.

2.2 Bathymetry and Topography

Hydrographic data were obtained from National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS) charts 12230 and 12263. Vertical and horizontal data are referenced to Mean Lower Low Water (MLLW) based on the 1960 to 1978 tidal epoch, and the Maryland State Plane, North American Datum of 1983. The five proposed dike alignments and existing bathymetry in the area of James Island are presented together in Figure 2-1. Figures 2-2 through 2-6 show each of the alignments, Alignment 1, 2, 3, 4 and 5 , respectively. Water depths within the site area vary between –2 to –12 ft MLLW. The maximum water depth where the exposed dike would be constructed is about –12 ft MLLW. Water depths approximately one mile west of James Island are as great as –93 ft MLLW.

2.3 Wind Conditions

Annual extreme windspeed data from NOAA, National Climatic Data Center (NCDC) for Baltimore-Washington International (BWI) Airport, for the period 1951 through 1982, were used in estimating wind conditions for this study (NOS 1982 and NCDC 1994). The BWI data are presented in Table 2-1 as fastest mile winds which are defined as the highest recorded wind speeds that last long enough to travel one mile during a 24 hour recording period. For example, a fastest mile wind speed of 60 miles per hour (mph) would have a duration of 60 seconds, a fastest mile wind speed of 50 mph would have a duration of 72 seconds, etc. The wind data presented in Table 2-1 were used to develop windspeed-return period relationships based on a Type I (Gumbel) distribution for eight directions; namely: north (N), northeast (NE), east (E), southeast (SE), south (S), southwest (SW), west (W) and northwest (NW). Return period is defined as the average time between wind events which equal or exceed a given value. The specific return periods examined were 5, 10, 15, 20, 25, 30, 35, 40, 50 and 100 years.

Table 2-1 Annual Extreme Wind Speed Per Direction for Baltimore -Washington International (BWI) Airport, 1951-1982 Fastest Mile Wind Speed (mph)

Year	N	NE	E	SE	S	SW	W	NW	All Directions
1951	24	41	27	34	39	29	42	46	46
1952	66	25	47	66	41	66	46	43	66
1953	20	28	22	27	34	39	47	43	47
1954	31	27	22	60	28	39	57	44	60
1955	21	43	29	28	43	53	40	43	53
1956	29	34	25	24	28	34	56	40	56
1957	29	53	35	33	33	30	46	46	53
1958	30	52	25	33	37	43	40	43	52
1959	28	26	20	27	23	38	46	43	46
1960	26	38	28	27	25	35	40	53	53
1961	45	28	28	29	24	70	41	54	70
1962	56	41	28	17	25	36	42	61	61
1963	38	32	18	34	25	28	44	60	60
1964	34	31	23	24	47	23	48	61	61
1965	36	26	28	34	36	54	44	44	54
1966	32	25	29	24	47	43	50	48	50
1967	30	29	25	39	27	46	53	43	53
1968	45	30	36	26	19	45	48	50	50
1969	28	21	20	34	26	45	45	53	53
1970	28	28	18	21	39	34	48	60	60
1971	31	45	26	18	21	41	39	58	58
1972	28	25	35	26	20	41	41	41	41
1973	40	26	26	38	26	35	49	33	49
1974	32	23	46	29	33	33	45	41	46
1975	40	26	21	24	25	38	54	45	54
1976	31	18	20	28	32	28	45	54	54
1977	32	31	19	28	26	25	49	48	49
1978	39	28	36	28	19	52	33	45	52
1979	32	25	27	36	32	32	45	47	47
1980	33	27	18	32	20	32	45	50	50
1981	24	24	19	26	23	28	41	42	42
1982	31	20	23	23	29	34	40	48	48

Note: Data adjusted to 10 meter height.

A review of the wind speed data indicate that during the 32-year period from 1951 through 1982, six wind events exceeded 60 mph. In order to quantify the frequency of various wind events, statistical analyses of the wind data were performed. These analyses consisted of fitting external statistical distributions through the annual extreme windspeeds for each of the wind directions and all of the directions. The wind statistics for each direction (design wind speeds) are presented in Table 2-2 in terms of fastest mile windspeeds for various return periods. Table 2-2 shows that the design windspeeds for a 35-year return period storm range from 51 mph for the east direction to 76 mph for the southwest direction. The design windspeeds presented in Table 2-2 have been used to estimate design wave conditions for the proposed project site in Section 2.5 of this report.

Table 2-2 Design Wind Speeds per Direction and Return Period (mph)

Return Period	Direction							
	N	NE	E	SE	S	SW	W	NW
5	40	37	32	37	36	47	50	54
10	48	44	38	45	43	56	54	59
15	52	48	41	50	47	61	56	62
20	56	52	45	55	51	67	59	65
25	59	55	47	58	54	70	60	67
30	62	57	49	61	56	73	61	68
35	64	60	51	63	58	76	62	70
40	66	62	53	65	60	78	63	71
50	69	66	55	69	63	82	64	73
100	81	76	65	82	74	97	69	81

2.4 Water Levels

Normal water level variations in the Chesapeake Bay are generally dominated by astronomical tides, although wind effects and freshwater discharge can be important. Extreme water levels, on the other hand, are dictated by storm tides.

2.5 Astronomical Tides

Astronomical tides in the Chesapeake Bay are semi-diurnal. The mean tide level is 0.9 ft above MLLW and the mean tidal range is 1.1 ft (NOS 1997). Tidal datums near the study area reported from NOS are presented in Table 2-3. Five data locations are shown in Table 2-3. MLLW will serve as the datum for this project.

Table 2-3 Astronomical Tidal Datum Characteristics for James Island Vicinity (ft, MLLW)

Tidal Datum	Cove Point	Sharps Island Light	Barren Island	Taylors Island/Slaughter Creek	Hooper Island
Mean Higher High Water (MHHW)	1.8	1.8	2.0	1.8	2.3
Mean High Water (MHW)	1.6	1.6	1.8	1.5	1.9
Mean Tide Level (MTL)	0.9	0.9	1.0	0.9	1.1
Mean Low Water (MLW)	0.3	0.3	0.2	0.3	0.4
Mean Lower Low Water (MLLW)	0.0	0.0	0.0	0.0	0.0

2.6 Storm Surge

Design water levels for the study site area are dominated by storm effects (i.e. storm surge and wave setup) in combination with astronomical tide. Storm surge is a temporary rise in water level generated either by large-scale extra-tropical storms known as northeasters, or by hurricanes. The rise in water level results from wind action, the low pressure of the storm disturbance and the Coriolis force. Wave setup is a term used to describe the rise in water level due to wave breaking. Specifically, change in momentum which attends the breaking of waves propagating towards shore results in a surf zone force that raises water levels at the shoreline. A comprehensive evaluation of storm-induced water levels for several Chesapeake Bay locations has been conducted by the Virginia Institute of Marine Science (VIMS) (1978) as part of the Federal Flood Insurance Program. Results of this study, summarized in Table 2-4, were used to generate the water-level vs. return period curve presented in Figure 2-7, which provides water levels in feet above MLLW for various return periods. Data in Figure 2-7 are for Hooper Island, the station in the report most representative for the project site. Hooper Island is approximately 18 miles south of the project site. The data presented in Figure 2-7 indicate that the storm tide elevation for a 35-year return period for Hooper Island is 4.5 ft MLLW and the 100-year water level is 5.6 ft MLLW.

Table 2-4 Storm Induced Water Level (ft, NGVD)

Return Period	Water Level
10	3.5
50	4.7
100	5.3
500	6.6

2.7 Wave Conditions

James Island is exposed to wind-generated waves from all directions. Wind-generated wave calculations were completed for the north, northeast, east, southeast, south, southwest, west and northwest directions.

In accordance with procedures recommended by the U.S. Army Corps of Engineers (USACE), Shore Protection Manual (SPM) (USACE 1984), a radially averaged fetch distance was computed for each direction. The radially averaged fetch distances for the N, NE, E, SE, S, SW, W and NW directions for the five alignments are shown in Figure 2-8. Table 2-5 presents radially averaged fetch distances and mean water depths corresponding to each direction for all alignments. Wave conditions were hindcast along each fetch direction for the design winds presented in Table 2-2 (adjusted appropriately for duration) and the water levels presented in Figure 2-7. Specifically, waves were hindcast for the eight directional design windspeeds (i.e. the design windspeeds computed for each individual direction) using methods published in the SPM (USACE 1984).

Table 2-5 Radially-Averaged Fetch Distances and Mean Water Depths Used for Wave Hindcasting – James Island

Direction	Mean Fetch Distance(Miles)	Mean Water Depth(ft, MLLW)
North	26.9	34.2
Northeast	5.3	9.6
East	5.3	12.2
Southeast	2.4	3.7
South	29.5	43.1
Southwest	6.9	39.8
West	8.3	35.4
Northwest	8.0	28.5

A sea state is normally composed of a spectrum of waves with varying heights and periods, which may range from relatively long waves to short ripples. In order to summarize the spectral characteristics of a sea state it is customary to represent that wave spectrum in terms of a distribution of wave energy over a range of wave periods. Having made this distribution, known as a wave spectrum, it is convenient to represent that wave spectrum by a single representative wave height and period. The wave conditions reported herein are the significant wave height, H_s, and the peak spectral wave period, T_p, respectively. The significant wave height, H_s, is defined as the average of the highest one-third of the waves in the spectrum. Depending on the duration of the storm condition represented by the wave spectrum, maximum wave heights may be as high as 1.8 to 2 times the significant wave height. The peak spectral period, T_p, is the wave period, which corresponds to the maximum wave energy level in the wave spectrum.

The random wave analyses of Goda (1985) were used to examine whether the offshore waves would break prior to reaching the dikes. The first step in examining wave conditions for a given bottom elevation and water level is to compute the total water depth from which the maximum breaking wave height can be determined. This breaker depth, h_b, is the sum of the selected water elevation above MLLW and the bottom elevation below MLLW. The maximum breaker height which can be supported in the resulting water depth is computed using the following formulae published in the SPM (USACE 1984):

$$h_b = \frac{H_b}{B_w - A_w \dfrac{H_b}{gT^2}}$$

$$B_w = \frac{1.56}{(1 + e^{(-19.5m)})}$$

$$A_w = 43.75\,(1 - e^{-19m})$$

Where:
- H_b = breaking wave height at the outer edge of the surf zone (ft)
- m = tangent of beach slope (unitless)
- h_b = breaker depth (ft)
- g = acceleration due to gravity (ft/sec^2)
- T = spectral wave period (sec)
- A_w, B_w = empirical breaking wave height parameters (unitless)

Solution to the above equation will provide an estimate of the maximum breaker height to which the structure is subjected for a given total water depth. Goda's analyses require the estimate of an equivalent offshore significant wave height (also referred to as the equivalent unrefracted wave height) which is computed from the maximum breaking wave height and the linear shoaling coefficient in accordance with the following equations:

$$H_s \approx \frac{H_b}{1.8}$$

$$H_o' = \frac{H_s}{K_s}$$

$$K_s = \sqrt{\frac{1}{\tanh\left(2\pi \frac{h_b}{L}\right)\left[1 + \frac{\frac{4\pi h_b}{L}}{\sinh\left(4\pi \frac{h_b}{L}\right)}\right]}}$$

$$L = \frac{gT^2}{2\pi} \tanh\ (2\pi \frac{h_b}{L})$$

Where:

H_s = approximate significant wave height at breaking (ft)

H_O = equivalent unrefracted deepwater significant wave height (ft)

K_s = shoaling coefficient (unitless)

L = local wave length (ft)

The H_{max} values are computed using the following equations published by Goda (1985):

$$H_{max} = 0.8K_s\ H_O \quad for \frac{h}{Lo} \geq 0.2$$

and

$$H_{max} = MIN\ [(\beta_O{}^* H_O' + \beta_1{}^* h), (\beta_{max}{}^* H_O'), (1.8\, K_S H_O')] \quad for \frac{h}{Lo} < 0.2$$

Where:

h = water depth (ft)

L_O = deepwater wave length (ft)

$$\beta_O{}^* = 0.052\left(\frac{H_O'}{Lo}\right)^{-0.38} e^{20.0\, m^{1.5}}$$

$$\beta_{max}* = MAX\left[1.65, 0.53\left(\frac{H_o'}{Lo}\right)^{-0.29} e^{2.4m}\right]$$

$$\beta_l* = 0.63\, e^{3.8m}$$

Similar equations are available for computing H_S, and the results are used to compute the nearshore significant and maximum wave heights.

2.7.1 Alignment 1

Alignment 1 is exposed to winds from the N, NE, E, SE, S, SW, W and NW. The radial fetches for Alignment 1 are shown in Figure 2-9. The mean fetch distance and mean water depth corresponding to each direction are shown in Table 2-5. Wave conditions were hindcast along each fetch direction for the design winds presented in Table 2-2 and the water levels presented in Figure 2-7. The design water depths in which the dikes in Alignment 1 would be constructed are shown in Table 2-6. Wave hindcast results for Alignment 1 are presented in Tables 2-7 and 2-8, for significant wave height (H_s) and peak spectral wave period (T_p), respectively. Figure 2-10 and 2-11 show polar plots for H_s and T_p, for Alignment 1. These figures present a summary of H_s and T_p that graphically show the directions from which the highest waves and longest periods approach the site.

For James Island, the highest waves are estimated to approach from both the north and south directions. For Alignment 1 the waves from the north direction have significant heights (H_s) of 5.4 ft, 8.2 ft and 10.1 ft, for the 5-year, 35-year and 100-year storms, respectively. The peak spectral wave periods (T_p) from the north direction are 4.9 seconds, 5.8 seconds and 6.4 seconds, for the 5-year, 35-year and 100-year storms, respectively.

Table 2-6 Water Depths at Proposed Dike James Island – Alignment 1

Direction	Water Depth(ft, MLLW)
North	7.0
Northeast	7.0
East	4.5
Southeast	4.5
South	5.0
Southwest	8.0
West	8.0
Northwest	7.0

Table 2-7 Offshore Significant Wave Heights (ft) James Island – Alignment 1

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	5.4	2.3	2.1	1.5	5.3	3.9	4.4	5.2
10	6.4	2.7	2.5	1.8	6.3	4.7	4.8	5.6
15	6.9	2.9	2.7	2.0	6.9	5.1	5.0	5.8
20	7.3	3.2	2.9	2.2	7.4	5.7	5.3	6.1
25	7.7	3.3	3.0	2.4	7.8	5.9	5.4	6.2
30	8.0	3.4	3.2	2.5	8.1	6.2	5.5	6.3
35	8.2	3.6	3.3	2.6	8.3	6.5	5.6	6.4
40	8.5	3.7	3.4	2.7	8.6	6.6	5.7	6.5
50	8.8	4.0	3.6	2.8	9.0	7.0	5.8	6.6
100	10.1	4.5	4.2	3.4	10.4	8.3	6.2	7.1

Table 2-8 Peak Spectral Wave Period (sec) James Island – Alignment 1

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	4.9	2.9	2.8	2.3	4.9	3.7	4	4.5
10	5.2	3.1	3.0	2.5	5.2	4.0	4.1	4.6
15	5.4	3.2	3.1	2.6	5.4	4.1	4.1	4.7
20	5.5	3.3	3.2	2.7	5.6	4.2	4.2	4.8
25	5.6	3.4	3.3	2.7	5.7	4.3	4.2	4.8
30	5.8	3.4	3.3	2.8	5.8	4.4	4.3	4.8
35	5.8	3.5	3.4	2.8	5.9	4.4	4.3	4.9
40	5.9	3.6	3.4	2.8	5.9	4.5	4.3	4.9
50	6.0	3.6	3.5	2.9	6.1	4.6	4.4	4.9
100	6.4	3.9	3.7	3.1	6.4	4.9	4.5	5.1

Tables 2-9 and 2-10 show the nearshore significant and nearshore maximum wave heights for Alignment 1. The corresponding polar plots are shown in Figures 2-12 and 2-13. Note that because the water is deeper north of James Island, the nearshore waves are relatively larger from the north direction. Table 2-9 shows that for the 5-year, 35-year and 100-year storms, the nearshore significant wave heights from the north are 4.6 ft, 5.1 ft and 5.6 ft, respectively. Table 2-10 shows that for Alignment 1, the nearshore maximum wave heights from the north direction are 7.6 ft, 8.6 ft and 9.6 ft, respectively.

Table 2-9 Nearshore Significant Wave Heights (ft) James Island – Alignment 1

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	4.6	2.3	2.1	1.5	3.8	3.9	4.4	4.5
10	4.7	2.7	2.5	1.8	3.9	4.7	4.8	4.6
15	4.8	2.9	2.7	2.0	4.0	4.9	4.9	4.7
20	4.9	3.2	2.9	2.2	4.0	5.0	5.0	4.7
25	4.9	3.3	3.0	2.4	4.1	5.0	5.0	4.8
30	5.0	3.4	3.2	2.5	4.2	5.1	5.1	4.9
35	5.1	3.6	3.3	2.6	4.3	5.2	5.1	4.9
40	5.1	3.7	3.4	2.7	4.3	5.3	5.2	5.0
50	5.3	4.0	3.6	2.8	4.5	5.4	5.3	5.1
100	5.6	4.5	4.1	3.4	4.7	5.7	5.6	5.4

Table 2-10 Nearshore Maximum Wave Heights (ft) James Island – Alignment 1

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	7.6	4.1	3.7	2.8	6.4	7.0	7.3	7.3
10	7.9	4.9	4.4	3.3	6.6	7.4	7.5	7.5
15	8.1	5.3	4.8	3.7	6.8	7.6	7.6	7.6
20	8.2	5.7	5.2	4.0	7.0	7.8	7.8	7.8
25	8.4	6.0	5.3	4.2	7.1	8.0	7.9	7.9
30	8.5	6.2	5.4	4.5	7.2	8.1	8.0	8.0
35	8.6	6.5	5.5	4.6	7.3	8.2	8.1	8.1
40	8.8	6.7	5.7	4.8	7.5	8.4	8.2	8.2
50	9.0	7.1	5.8	5.1	7.7	8.6	8.4	8.4
100	9.6	7.6	6.3	5.6	8.2	9.2	8.8	8.8

2.7.2 Alignment 2

Alignment 2 is exposed to winds from the N, NE, E, SE, S, SW, W and NW. The radial fetches for Alignment 2 are shown in Figure 2-14. The mean fetch distance and mean water depth corresponding to each direction are shown in Table 2-5. Wave conditions were hindcast along each fetch direction for the design winds presented in Table 2-2 and the water levels presented in Figure 2-7. The design water depths where the dikes for Alignment 2 are proposed are shown in Table 2-11. Wave hindcast results for Alignment 2 are presented in Tables 2-12 and 2-13, for significant wave height (H_s) and peak spectral wave period (T_p), respectively. Figure 2-15 and 2-16 show polar plots for H_s and T_p. for Alignment 2. These figures present a summary of H_s and T_p that graphically show the directions from which the highest waves and longest periods approach the site.

For Alignment 2 at James Island, the highest non-breaking waves are estimated to approach from both the north and south directions, with significant heights (H_s) from the north of 5.4 ft, 8.2 ft and 10.1 ft, for the 5-year, 35-year and 100-year storms, respectively. The peak spectral wave period (T_p) for Alignment 2, from the north direction is 4.9 seconds, 5.8 seconds and 6.4 seconds, for the 5-year, 35-year and 100-year storms, respectively.

Table 2-11 Water Depth at Proposed Dike James Island – Alignment 2

Direction	Water Depth(ft, MLLW)
North	8.0
Northeast	8.5
East	4.5
Southeast	4.5
South	7.0
Southwest	9.0
West	9.0
Northwest	8.0

Table 2-12 Offshore Significant Wave Heights (ft) James Island – Alignment 2

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	5.4	2.3	2.1	1.5	5.3	3.9	4.4	5.2
10	6.4	2.7	2.5	1.8	6.3	4.7	4.8	5.6
15	6.9	2.9	2.7	2.0	6.9	5.1	5.0	5.8
20	7.3	3.2	2.9	2.2	7.4	5.7	5.3	6.1
25	7.7	3.3	3.0	2.4	7.8	5.9	5.4	6.2
30	8.0	3.4	3.2	2.5	8.1	6.2	5.5	6.3
35	8.2	3.6	3.3	2.6	8.3	6.5	5.6	6.4
40	8.5	3.7	3.4	2.7	8.6	6.6	5.7	6.5
50	8.8	4.0	3.6	2.8	9.0	7.0	5.8	6.6
100	10.1	4.5	4.2	3.4	10.4	8.3	6.2	7.1

Table 2-13 Peak Spectral Wave Period (sec) James Island – Alignment 2

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	4.9	2.9	2.8	2.3	4.9	3.7	4.0	4.5
10	5.2	3.1	3.0	2.5	5.2	4.0	4.1	4.6
15	5.4	3.2	3.1	2.6	5.4	4.1	4.1	4.7
20	5.5	3.3	3.2	2.7	5.6	4.2	4.2	4.8
25	5.6	3.4	3.3	2.7	5.7	4.3	4.2	4.8
30	5.8	3.4	3.3	2.8	5.8	4.4	4.3	4.8
35	5.8	3.5	3.4	2.8	5.9	4.4	4.3	4.9
40	5.9	3.6	3.4	2.8	5.9	4.5	4.3	4.9
50	6.0	3.6	3.5	2.9	6.1	4.6	4.4	4.9
100	6.4	3.9	3.7	3.1	6.4	4.9	4.5	5.1

For Alignment 2, the highest breaking waves are estimated to approach from the north direction, although deeper water towards the south, southwest, west, and northwest allow comparably large waves at the higher return periods. Tables 2-14 and 2-15 show the nearshore significant and nearshore maximum wave heights for Alignment 2. The corresponding polar plots are shown in Figures 2-17 and 2-18. Table 2-14 shows that for Alignment 2, the 5-year, 35-year and 100-year nearshore significant wave heights from the north are 5.0 ft, 5.5 ft and 6.0 ft, respectively. Table 2-15 shows that for the 5-year, 35-year and 100-year storms, the nearshore maximum wave heights from the north are 8.1 ft, 9.3 ft and 10.2 ft, respectively.

Table 2-14 Nearshore Significant Wave Heights (ft)James Island – Alignment 2

Return Period (years)	N	NE	Et	SE	Sh	SW	W	NW
5	5.0	2.3	2.1	1.5	4.6	3.9	4.4	4.9
10	5.1	2.7	2.5	1.8	4.7	4.7	4.8	5.0
15	5.2	2.9	2.7	2.0	4.8	5.1	5.0	5.0
20	5.3	3.2	2.9	2.2	4.9	5.3	5.3	5.1
25	5.3	3.3	3.0	2.4	4.9	5.4	5.4	5.2
30	5.4	3.4	3.2	2.5	5.0	5.5	5.4	5.2
35	5.5	3.6	3.3	2.6	5.1	5.5	5.5	5.3
40	5.6	3.7	3.4	2.7	5.2	5.6	5.6	5.4
50	5.7	4.0	3.6	2.8	5.3	5.7	5.7	5.5
100	6.0	4.5	4.1	3.4	5.6	6.1	5.9	5.8

Table 2-15 Nearshore Maximum Wave Heights (ft) James Island – Alignment 2

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.1	4.1	3.7	2.8	7.6	7.0	7.7	7.9
10	8.5	4.9	4.4	3.3	7.9	7.8	8.0	8.0
15	8.7	5.3	4.8	3.7	8.1	8.0	8.1	8.2
20	8.8	5.7	5.2	4.0	8.2	8.3	8.3	8.3
25	9.0	6.0	5.3	4.2	8.4	8.4	8.4	8.4
30	9.1	6.2	5.4	4.5	8.5	8.6	8.5	8.5
35	9.3	6.5	5.5	4.6	8.7	8.7	8.5	8.6
40	9.4	6.7	5.7	4.8	8.8	8.8	8.6	8.7
50	9.6	7.2	5.8	5.1	9.0	9.1	8.8	8.9
100	10.2	8.1	6.3	5.6	9.6	9.7	9.2	9.4

2.7.3 Alignment 3

Alignment 3 is exposed to winds from the N, NE, E, SE, S, SW, W and NW. The radial fetches for Alignment 3 are shown in Figure 2-19. The mean fetch distance and mean water depth corresponding to each direction are shown in Table 2-5. Wave conditions were hindcast along each fetch direction for the design winds presented in Table 2-2 and the water levels presented in Figure 2-7. The design water depths where the dikes for Alignment 3 are proposed are shown in Table 2-16. Wave hindcast results for Alignment 3 are presented in Tables 2-17 and 2-18, for significant wave height (H_s) and peak spectral wave period (T_p), respectively. Figure 2-20 and 2-21 show polar plots for H_s and T_p for Alignment 3. These figures present a summary of H_s and T_p that graphically show the directions from which the highest waves and longest periods approach the site.

For Alignment 3 at James Island, the highest non-breaking waves are estimated to approach from both the north and south directions, with significant wave heights (H_s) from the north of 5.4 ft, 8.2 ft and 10.1 ft, for the 5-year, 35-year and 100-year storms, respectively. The peak spectral wave period (T_p) for Alignment 2, from the north direction is 4.9 seconds, 5.8 seconds and 6.4 seconds, for the 5-year, 35-year and 100-year storms, respectively.

Table 2-16 Water Depth at Proposed Dike James Island – Alignment 3

Direction	Water Depth (ft, MLLW)
North	9.0
Northeast	9.0
East	6.0
Southeast	6.0
South	7.0
Southwest	7.0
West	7.5
Northwest	8.0

Table 2-17 Offshore Significant Wave Heights (ft) James Island – Alignment 3

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	5.4	2.3	2.1	1.5	5.3	3.9	4.4	5.2
10	6.4	2.7	2.5	1.8	6.3	4.7	4.8	5.6
15	6.9	2.9	2.7	2.0	6.9	5.1	5.0	5.8
20	7.3	3.2	2.9	2.2	7.4	5.7	5.3	6.1
25	7.7	3.3	3.0	2.4	7.8	5.9	5.4	6.2
30	8.0	3.4	3.2	2.5	8.1	6.2	5.5	6.3
35	8.2	3.6	3.3	2.6	8.3	6.5	5.6	6.4
40	8.5	3.7	3.4	2.7	8.6	6.6	5.7	6.5
50	8.8	4.0	3.6	2.8	9.0	7.0	5.8	6.6
100	10.1	4.5	4.2	3.4	10.4	8.3	6.2	7.1

Table 2-18 Peak Spectral Wave Period (sec) James Island – Alignment 3

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	4.9	2.9	2.1	2.3	4.9	3.7	4.0	4.5
10	5.2	3.1	2.5	2.5	5.2	4.0	4.1	4.6
15	5.4	3.2	2.7	2.6	5.4	4.1	4.1	4.7
20	5.5	3.3	2.9	2.7	5.6	4.2	4.2	4.8
25	5.6	3.4	3.0	2.7	5.7	4.3	4.2	4.8
30	5.8	3.4	3.2	2.8	5.8	4.4	4.3	4.8
35	5.8	3.5	3.3	2.8	5.9	4.4	4.3	4.9
40	5.9	3.6	3.4	2.8	5.9	4.5	4.3	4.9
50	6.0	3.6	3.6	2.9	6.1	4.6	4.4	4.9
100	6.4	3.9	4.2	3.1	6.4	4.9	4.5	5.1

For Alignment 3, the highest breaking waves are estimated to approach from the north direction. Tables 2-19 and 2-20 show the nearshore significant and nearshore maximum wave heights for Alignment 3. The corresponding polar plots are shown in Figures 2-22 and 2-23. Table 2-19 shows that for Alignment 3, the nearshore significant wave heights from the north are 5.3 ft, 5.9 ft and 6.4 ft, for the 5-year, 35-year and 100-year storms, respectively. Table 2-20 shows that for the 5-year, 35-year and 100-year storms, the nearshore maximum wave heights from the north are 8.7 ft, 9.9 ft, and 10.8 ft.

Table 2-19 Nearshore Significant Wave Heights (ft) James Island – Alignment 3

Return Period (years)	North	Northeast	East	Southeast	South	Southwest	West	Northwest
5	5.3	2.3	2.1	1.5	4.6	3.9	4.4	4.9
10	5.5	2.7	2.5	1.8	4.7	4.4	4.6	5.0
15	5.6	2.9	2.7	2.0	4.8	4.5	4.7	5.0
20	5.7	3.2	2.9	2.2	4.9	4.6	4.8	5.1
25	5.7	3.3	3.0	2.4	4.9	4.7	4.8	5.2
30	5.8	3.4	3.2	2.5	5.0	4.7	4.9	5.2
35	5.9	3.6	3.3	2.6	5.1	4.8	5.0	5.3
40	6.0	3.7	3.4	2.7	5.2	4.9	5.0	5.4
50	6.1	4.0	3.6	2.8	5.3	5.0	5.1	5.5
100	6.4	4.5	4.2	3.4	5.6	5.3	5.4	5.8

Table 2-20 Nearshore Maximum Wave Heights (ft) James Island – Alignment 3

Return Period (years)	North	Northeast	East	Southeast	South	Southwest	West	Northwest
5	8.7	4.1	3.7	2.8	7.6	6.6	7.1	7.9
10	9.0	4.9	4.4	3.3	7.9	6.9	7.3	8.0
15	9.2	5.3	4.8	3.7	8.1	7.1	7.4	8.2
20	9.4	5.7	5.2	4.0	8.2	7.3	7.6	8.3
25	9.6	6.0	5.5	4.2	8.4	7.5	7.7	8.4
30	9.7	6.2	5.7	4.5	8.5	7.6	7.8	8.5
35	9.9	6.5	5.9	4.6	8.7	7.7	7.9	8.6
40	10.0	6.7	6.2	4.8	8.8	7.9	8.0	8.7
50	10.2	7.2	6.4	5.1	9.0	8.1	8.1	8.9
100	10.8	8.2	7.0	6.1	9.6	8.7	8.6	9.4

2.7.4 Alignment 4

Alignment 4 is exposed to winds from the N, NE, E, SE, S, SW, W and NW. The radial fetches for Alignment 4 are shown in Figure 2-24. The mean fetch distance and mean water depth corresponding to each direction are shown in Table 2-5. Wave conditions were hindcast along each fetch direction for the design winds presented in Table 2-2 and the water levels presented in Figure 2-7. The design water depths where the dikes in Alignment 4 are proposed are shown in Table 2-21. Wave hindcast results for Alignment 4 are presented in Tables 2-22 and 2-23, for significant wave height (H_s) and peak spectral wave period (T_p), respectively. Figure 2-25 and 2-26 show polar plots for H_s and T_p, for Alignment 4. These figures present a summary of H_s and T_p that graphically show the directions from which the highest waves and longest periods approach the site.

For James Island, the highest waves are estimated to approach from the both the north and south directions. For Alignment 4, the waves from the north direction have significant heights (H_s) of 5.4 ft, 8.2 ft and 10.1 ft, for the 5-year, 35-year and 100-year storms, respectively. For Alignment 4, the peak spectral wave period (T_p) from the north direction is 4.9 seconds, 5.8 seconds and 6.4 seconds, for the 5-year, 35-year and 100-year storms, respectively.

Table 2-21 Water Depth at Proposed Dike James Island – Alignment 4

Direction	Water Depth (ft, MLLW)
North	8.5
Northeast	9.0
East	6.0
Southeast	6.0
South	7.0
Southwest	12.0
West	12.0
Northwest	8.0

Table 2-22 Offshore Significant Wave Heights (ft) James Island – Alignment 4

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	5.4	2.3	2.1	1.5	5.3	3.9	4.4	5.2
10	6.4	2.7	2.5	1.8	6.3	4.7	4.8	5.6
15	6.9	2.9	2.7	2.0	6.9	5.1	5.0	5.8
20	7.3	3.2	2.9	2.2	7.4	5.7	5.3	6.1
25	7.7	3.3	3.0	2.4	7.8	5.9	5.4	6.2
30	8.0	3.4	3.2	2.5	8.1	6.2	5.5	6.3
35	8.2	3.6	3.3	2.6	8.3	6.5	5.6	6.4
40	8.5	3.7	3.4	2.7	8.6	6.6	5.7	6.5
50	8.8	4.0	3.6	2.8	9.0	7.0	5.8	6.6
100	10.1	4.5	4.2	3.4	10.4	8.3	6.2	7.1

Table 2-23 Peak Spectral Wave Period (sec) James Island – Alignment 4

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	4.9	2.9	2.1	2.3	4.9	3.7	4.0	4.5
10	5.2	3.1	2.5	2.5	5.2	4.0	4.1	4.6
15	5.4	3.2	2.7	2.6	5.4	4.1	4.1	4.7
20	5.5	3.3	2.9	2.7	5.6	4.2	4.2	4.8
25	5.6	3.4	3.0	2.7	5.7	4.3	4.2	4.8
30	5.8	3.4	3.2	2.8	5.8	4.4	4.3	4.8
35	5.8	3.5	3.3	2.8	5.9	4.4	4.3	4.9
40	5.9	3.6	3.4	2.8	5.9	4.5	4.3	4.9
50	6.0	3.6	3.6	2.9	6.1	4.6	4.4	4.9
100	6.4	3.9	4.2	3.1	6.4	4.9	4.5	5.1

Tables 2-24 and 2-25 show the nearshore significant and nearshore maximum wave heights for Alignment 4. The corresponding polar plots are shown in Figures 2-27 and 2-28. Table 2-24 shows that for the 5-year, 35-year and 100-year storms, the nearshore significant wave heights from the north are 5.1 ft, 5.7 ft and 6.2 ft, respectively. Table 2-25 shows that for Alignment 4, the nearshore maximum wave heights for north direction are 8.4 ft, 9.6 ft and 10.5 ft, for the 5-year, 35-year and 100-year storms, respectively. For this alignment, the deepest water in which the dikes would be constructed is in the southwest, thus the largest nearshore waves are from the southwest (for the higher return periods). The 35-year and 100-year nearshore waves from the southwest are 6.5 ft and 7.1 ft, respectively. The nearshore maximum from the southwest are 10.0 ft and 11.0 ft for the 35-year and 100-year storms, respectively.

Table 2-24 Nearshore Significant Wave Heights (ft) James Island – Alignment 4

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	5.1	2.3	2.1	1.5	4.6	3.9	4.4	4.9
10	5.3	2.7	2.5	1.8	4.7	4.7	4.8	5.0
15	5.4	2.9	2.7	2.0	4.8	5.1	5.0	5.0
20	5.5	3.2	2.9	2.2	4.9	5.7	5.3	5.1
25	5.5	3.3	3.0	2.4	4.9	5.9	5.4	5.2
30	5.6	3.4	3.2	2.5	5.0	6.2	5.5	5.2
35	5.7	3.6	3.3	2.6	5.1	6.5	5.6	5.3
40	5.8	3.7	3.4	2.7	5.2	6.6	5.7	5.4
50	5.9	4.0	3.6	2.8	5.3	6.8	5.8	5.5
100	6.2	4.5	4.2	3.4	5.6	7.1	6.2	5.8

Table 2-25 Nearshore Maximum Wave Heights (ft) James Island – Alignment 4

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.4	4.1	3.7	2.8	7.6	7.0	8.0	7.9
10	8.8	4.9	4.4	3.3	7.9	8.5	8.7	8.0
15	9.0	5.3	4.8	3.7	8.1	9.2	9.0	8.2
20	9.1	5.7	5.2	4.0	8.2	9.5	9.5	8.3
25	9.3	6.0	5.5	4.2	8.4	9.6	9.6	8.4
30	9.4	6.2	5.7	4.5	8.5	9.8	9.7	8.5
35	9.6	6.5	5.9	4.6	8.7	10.0	9.8	8.6
40	9.7	6.7	6.2	4.8	8.8	10.1	9.9	8.7
50	9.9	7.2	6.4	5.1	9.0	10.4	10.0	8.9
100	10.5	8.2	7.0	6.1	9.6	11.0	10.5	9.4

2.7.5 Alignment 5

Alignment 5 is exposed to winds from the N, NE, E, SE, S, SW, W and NW. The radial fetches for Alignment 5 are shown in Figure 2-29. The mean fetch distance and mean water depth corresponding to each direction are shown in Table 2-5. Wave conditions were hindcast along each fetch direction for the design winds presented in Table 2-2 and the water levels presented in Figure 2-7. The design water depths where the dikes for Alignment 5 are proposed are shown in Table 2-26. Wave hindcast results for Alignment 5 are presented in Tables 2-27 and 2-28, for significant wave height (H_s) and peak spectral wave period (T_p), respectively. Figure 2-30 and 2-31 show polar plots for H_s and T_p, for Alignment 5. These figures present a summary of H_s and T_p that graphically show the directions from which the highest waves and longest periods approach the site.

For Alignment 5 at James Island, the highest non-breaking waves are estimated to approach from both the north and south directions. The waves from the north direction have significant heights (H_s) of 5.4 ft, 8.2 ft and 10.1 ft, for the 5-year, 35-year and 100-year storms, respectively. The peak spectral wave periods (T_p) from the south direction is 4.9 seconds, 5.8 seconds and 6.4 seconds, for the 5-year, 35-year and 100-year storms, respectively.

Table 2-26 Water Depth at Proposed Dike James Island – Alignment 5

Direction	Water Depth (ft, MLLW)
North	8.5
Northeast	9.0
East	6.0
Southeast	6.0
South	7.0
Southwest	12.0
West	12.0
Northwest	8.0

Table 2-27 Offshore Significant Wave Heights (ft) James Island – Alignment 5

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	5.4	2.4	2.1	1.5	5.3	3.9	4.4	5.2
10	6.4	2.9	2.5	1.8	6.3	4.7	4.8	5.6
15	6.9	3.1	2.7	2.0	6.9	5.1	5.0	5.8
20	7.3	3.3	2.9	2.2	7.4	5.7	5.3	6.1
25	7.7	3.5	3.0	2.4	7.8	5.9	5.4	6.2
30	8.0	3.6	3.2	2.5	8.1	6.2	5.5	6.3
35	8.2	3.8	3.3	2.6	8.3	6.5	5.6	6.4
40	8.5	3.9	3.4	2.7	8.6	6.6	5.7	6.5
50	8.8	4.2	3.6	2.8	9.0	7.0	5.8	6.6
100	10.1	4.7	4.2	3.4	10.4	8.3	6.2	7.1

Table 2-28 Peak Spectral Wave Period (sec) James Island – Alignment 5

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	4.9	2.9	2.1	2.3	4.9	3.7	4.0	4.5
10	5.2	3.1	2.5	2.5	5.2	4.0	4.1	4.6
15	5.4	3.2	2.7	2.6	5.4	4.1	4.1	4.7
20	5.5	3.3	2.9	2.7	5.6	4.2	4.2	4.8
25	5.6	3.4	3.0	2.7	5.7	4.3	4.2	4.8
30	5.8	3.4	3.2	2.8	5.8	4.4	4.3	4.8
35	5.8	3.5	3.3	2.8	5.9	4.4	4.3	4.9
40	5.9	3.6	3.4	2.8	5.9	4.5	4.3	4.9
50	6.0	3.6	3.6	2.9	6.1	4.6	4.4	4.9
100	6.4	3.9	4.2	3.1	6.4	4.9	4.5	5.1

Similarly to Alignment 4, for Alignment 5, the highest breaking waves are estimated to approach from the north, southwest and west directions. Tables 2-29 and 2-30 show the nearshore significant and nearshore maximum wave heights for Alignment 5. The corresponding polar plots are shown in Figures 2-32 and 2-33. Table 2-29 shows that for Alignment 5, the nearshore significant wave heights from the north are 5.1 ft, 5.7 ft and 6.2 ft, respectively and from the southwest are 6.5 ft and 7.1 ft for a 35-year and 100-year storm, respectively. Table 2-30 shows that for the 5-year, 35-year and 100-year storms, the nearshore maximum wave heights from the north are 8.4 ft, 9.6 ft and 10.5 ft, respectively, and from the southwest are 10.0 ft and 11.0 ft for 35-year and 100-year storms, respectively.

Table 2-29 Nearshore Significant Wave Heights (ft) James Island – Alignment 5

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	5.1	2.3	2.1	1.5	4.6	3.9	4.4	4.9
10	5.3	2.7	2.5	1.8	4.7	4.7	4.8	5.0
15	5.4	2.9	2.7	2	4.8	5.1	5.0	5.0
20	5.5	3.2	2.9	2.2	4.9	5.7	5.3	5.1
25	5.5	3.3	3	2.4	4.9	5.9	5.4	5.2
30	5.6	3.4	3.2	2.5	5.0	6.2	5.5	5.2
35	5.7	3.6	3.3	2.6	5.1	6.5	5.6	5.3
40	5.8	3.7	3.4	2.7	5.2	6.6	5.7	5.4
50	5.9	4.0	3.6	2.8	5.3	6.8	5.8	5.5
100	6.2	4.5	4.2	3.4	5.6	7.1	6.2	5.8

Table 2-30 Nearshore Maximum Wave Heights (ft) James Island – Alignment 5

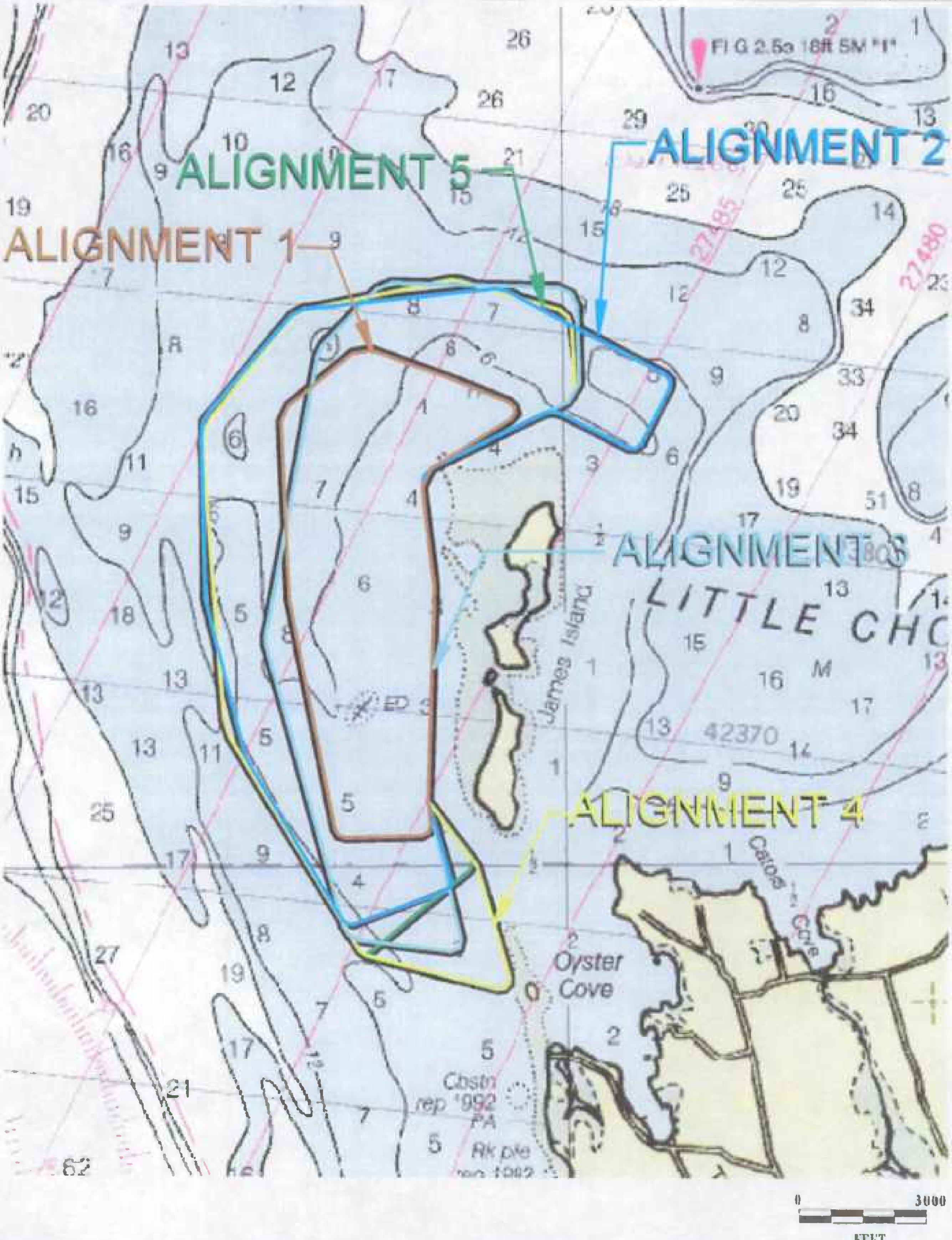
Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.4	4.1	3.7	2.8	7.6	7.0	8.0	7.9
10	8.8	4.9	4.4	3.3	7.9	8.5	8.7	8.0
15	9.0	5.3	4.8	3.7	8.1	9.2	9.0	8.2
20	9.1	5.7	5.2	4.0	8.2	9.5	9.5	8.3
25	9.3	6.0	5.5	4.2	8.4	9.6	9.6	8.4
30	9.4	6.2	5.7	4.5	8.5	9.8	9.7	8.5
35	9.6	6.5	5.9	4.6	8.7	10.0	9.8	8.6
40	9.7	6.7	6.2	4.8	8.8	10.1	9.9	8.7
50	9.9	7.2	6.4	5.1	9.0	10.4	10.0	8.9
100	10.5	8.2	7.0	6.1	9.6	11.0	10.5	9.4

2.8 Currents

Currents in the vicinity of James Island are less than 1 ft/sec (NOS 1996), which is relatively moderate to weak, and are not anticipated to govern dike design. Current patterns will, however, be impacted by island restoration. A detailed examination of tidal currents will be presented in the Hydrodynamics and Sedimentation Modeling Report for this study.

2.9 Soil Characteristics

An evaluation of the soil characteristics at the project site was performed by Engineering Consultation Construction Remediation, Inc. (E2CR 2002). The evaluation included performing soil borings, preparing soil boring profiles, identifying soil strata thickness, location and characteristics, and conducting a preliminary slope stability analysis. Results of the preliminary study indicate that the underlying soil consists of silty sand. However, areas with soft silty clays at the mud line will need to be undercut and backfilled with sand.



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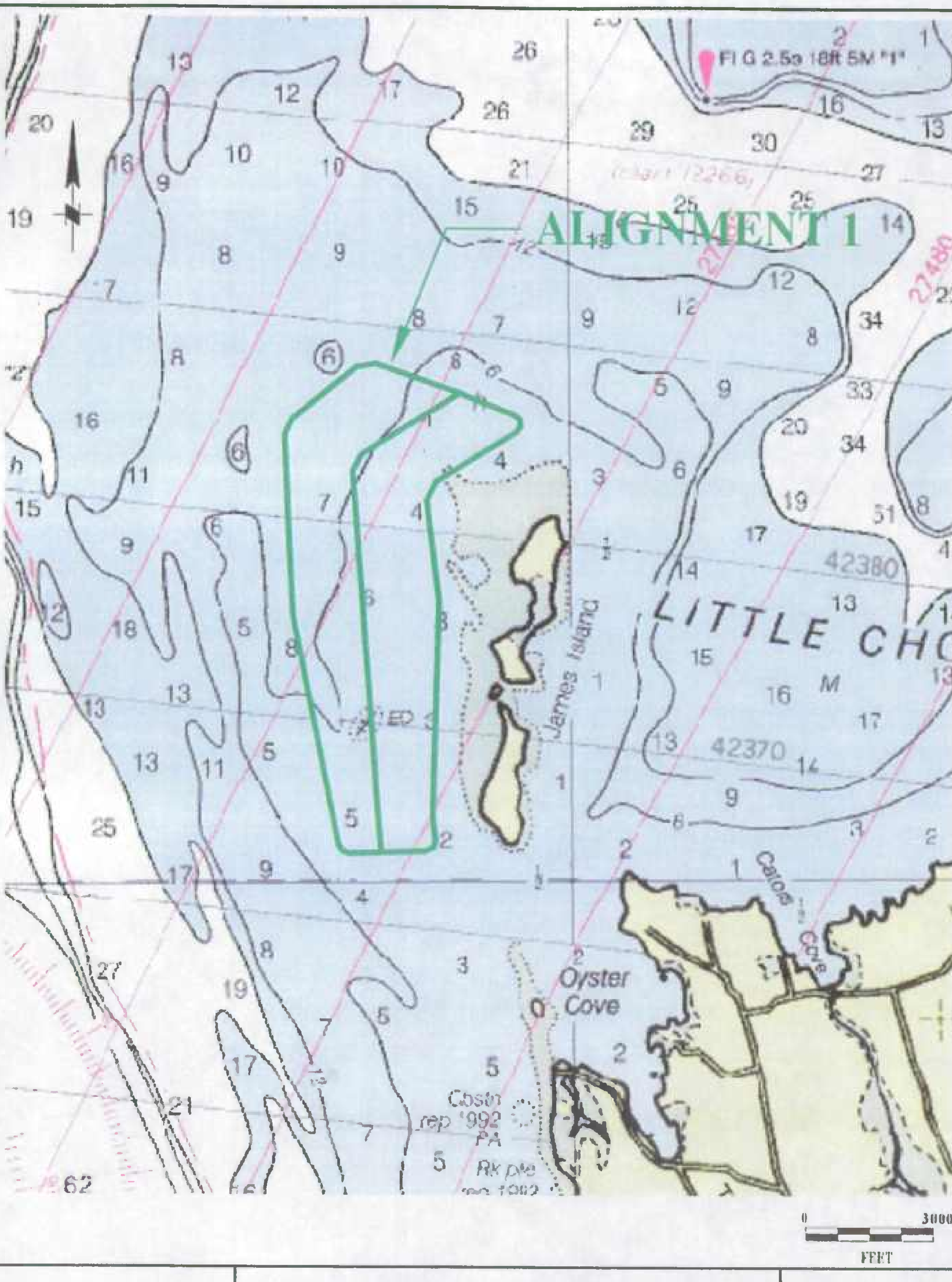
JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 2-1
FIVE PROPOSED DIKE ALIGNMENTS



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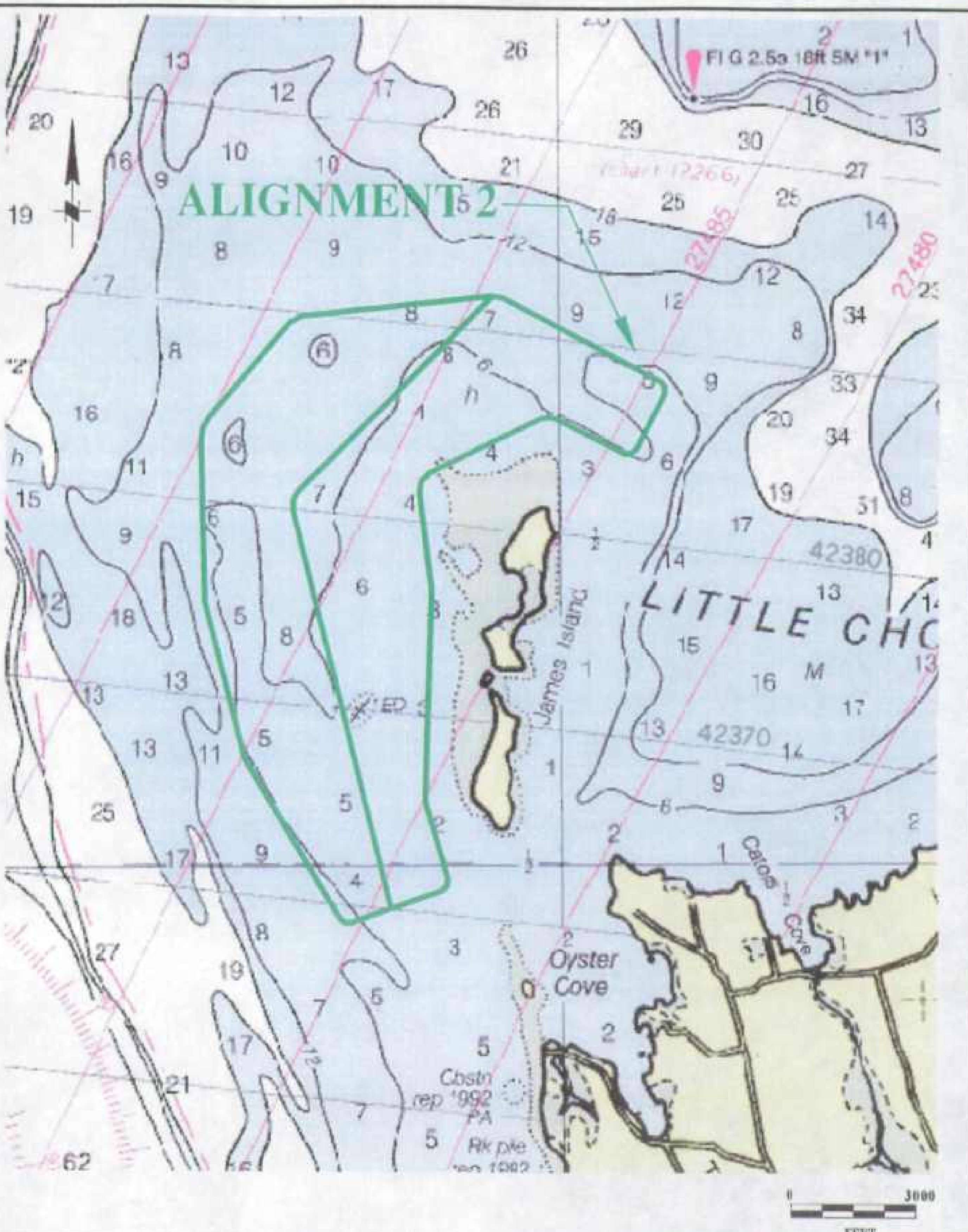
JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 2-2
PROPOSED DIKE ALIGNMENT 1



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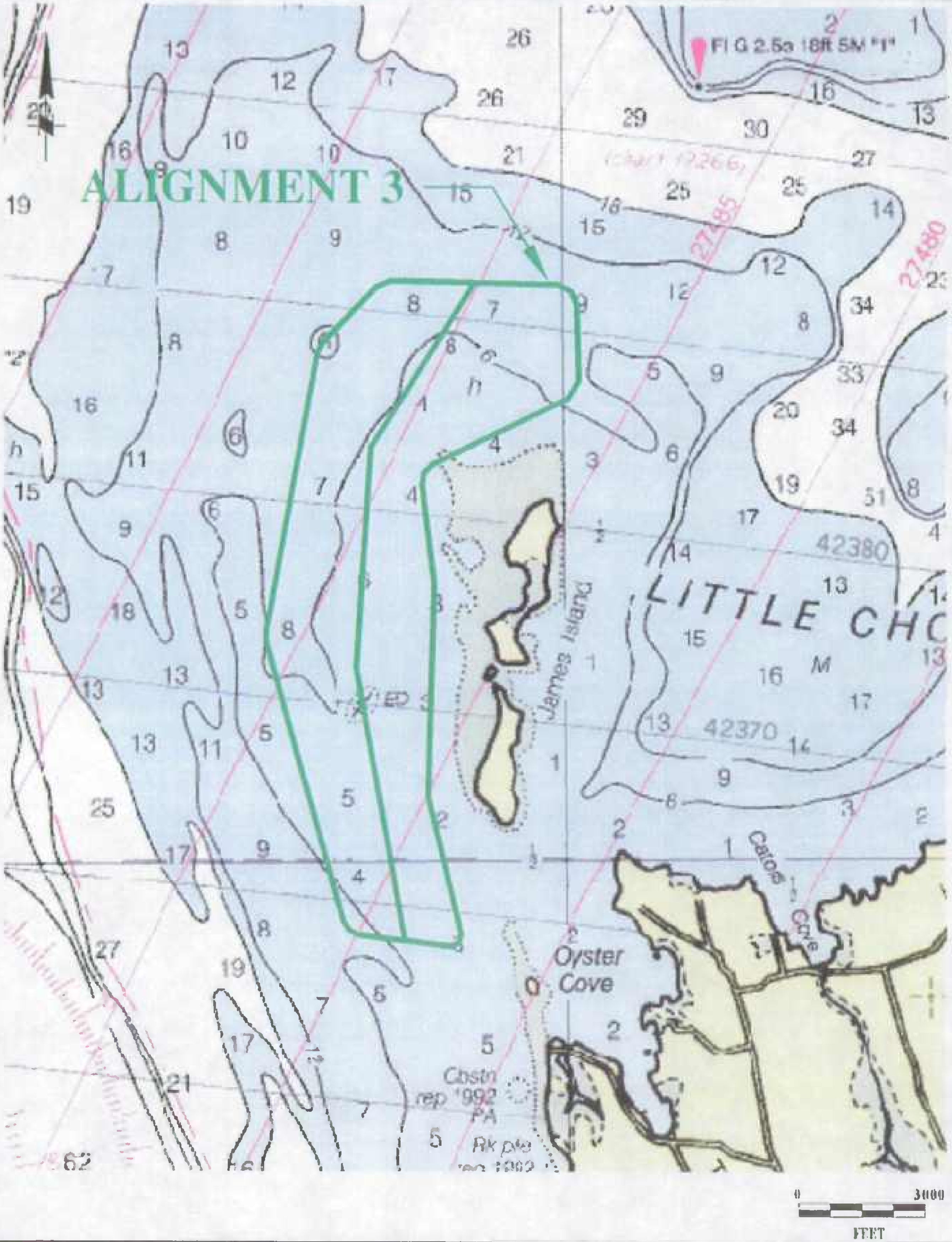
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 2-3
PROPOSED DIKE
ALIGNMENT 2



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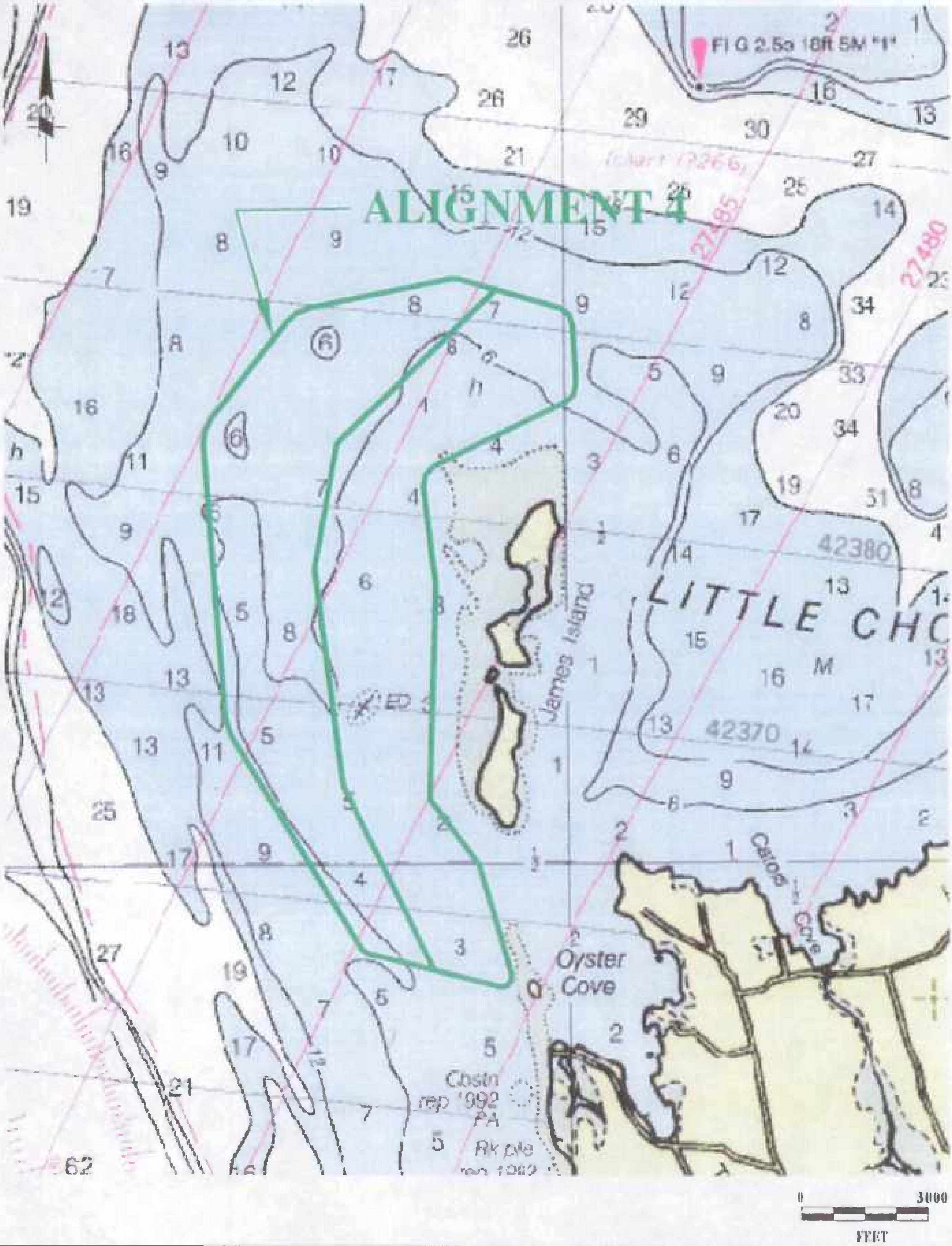
JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 2-4
PROPOSED DIKE
ALIGNMENT 3



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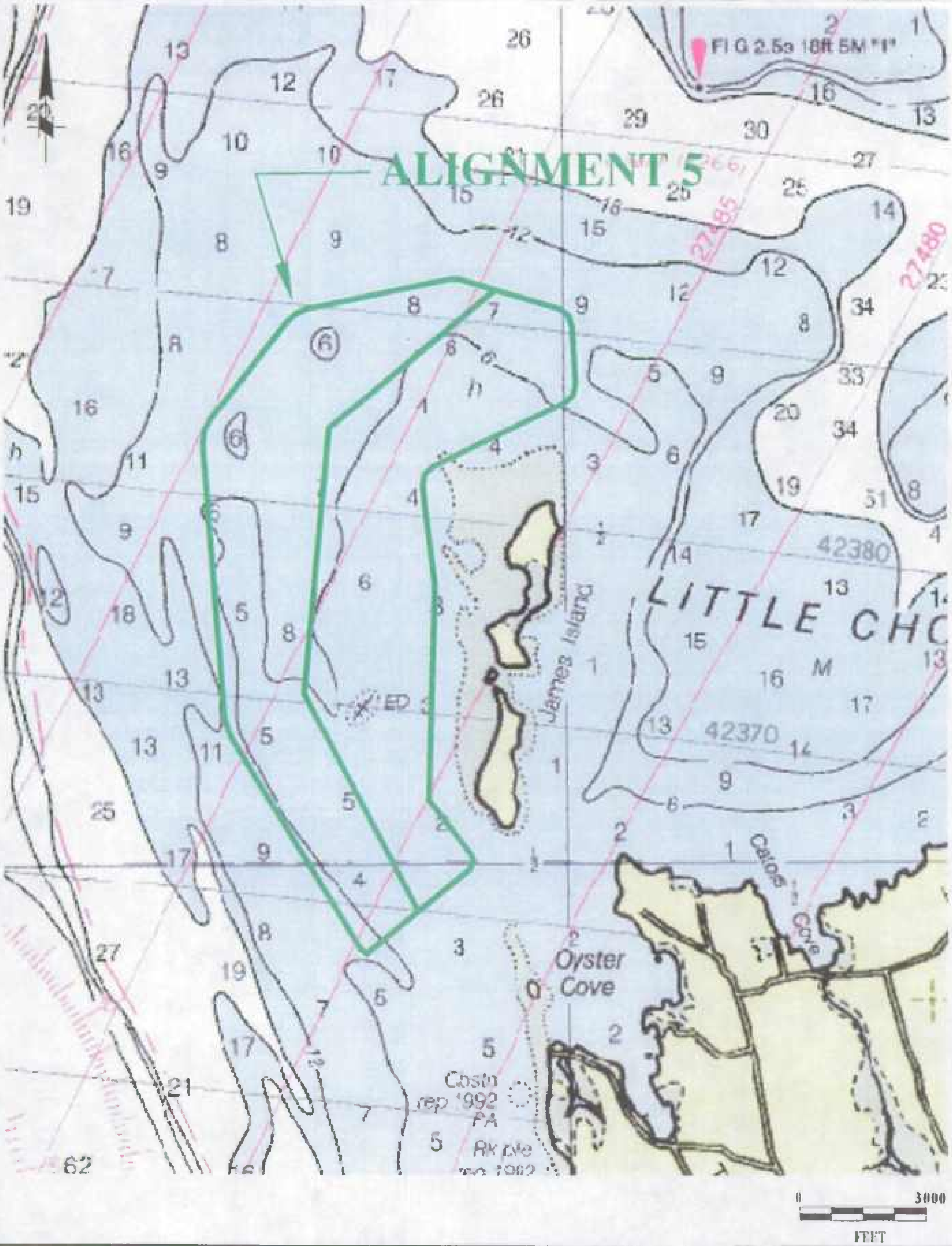
JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 2-5
PROPOSED DIKE
ALIGNMENT 4



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JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 2-6
PROPOSED DIKE
ALIGNMENT 5

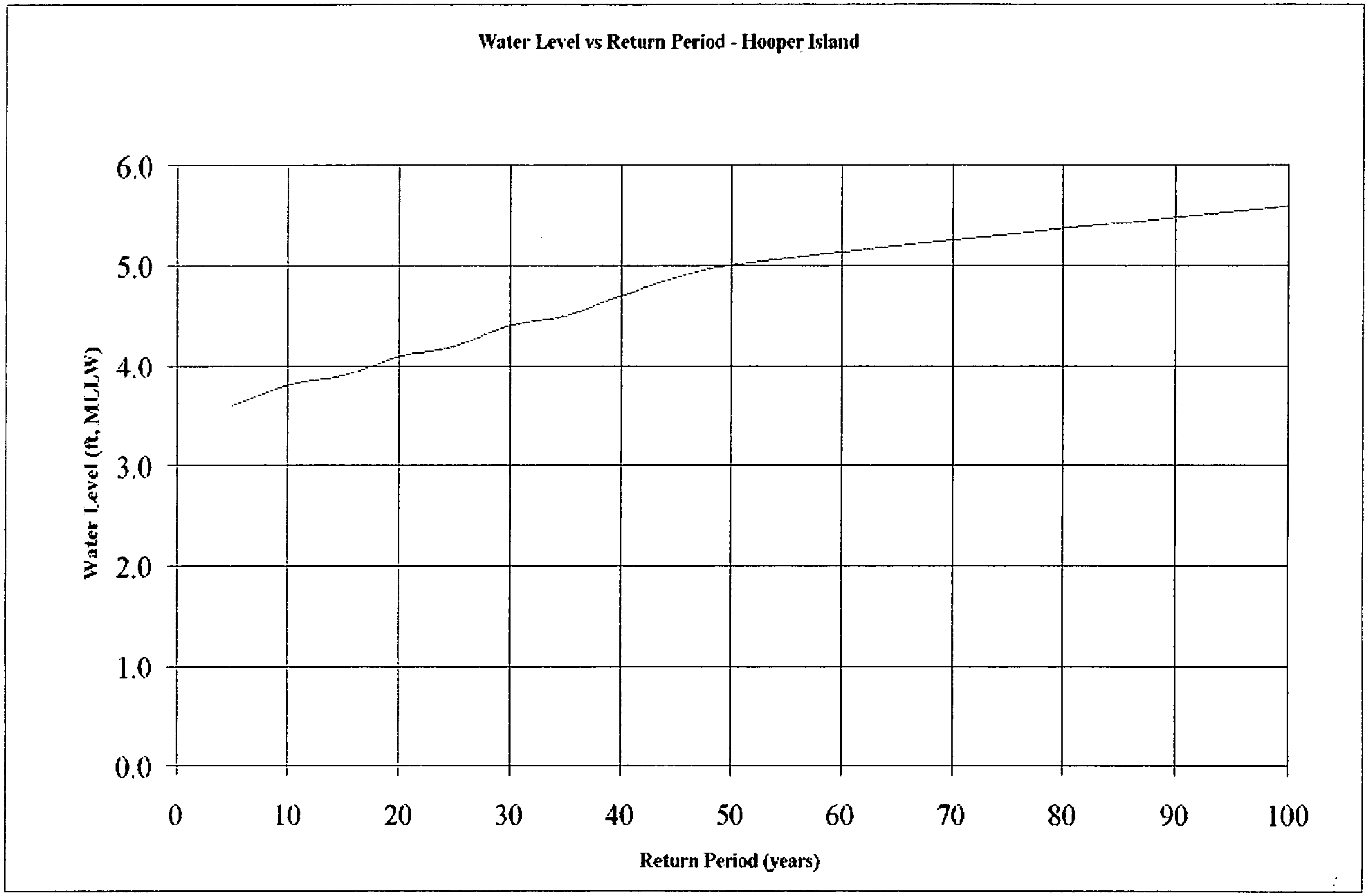

Figure 2-7. Design Water Levels (ft, MLLW) for James Island.

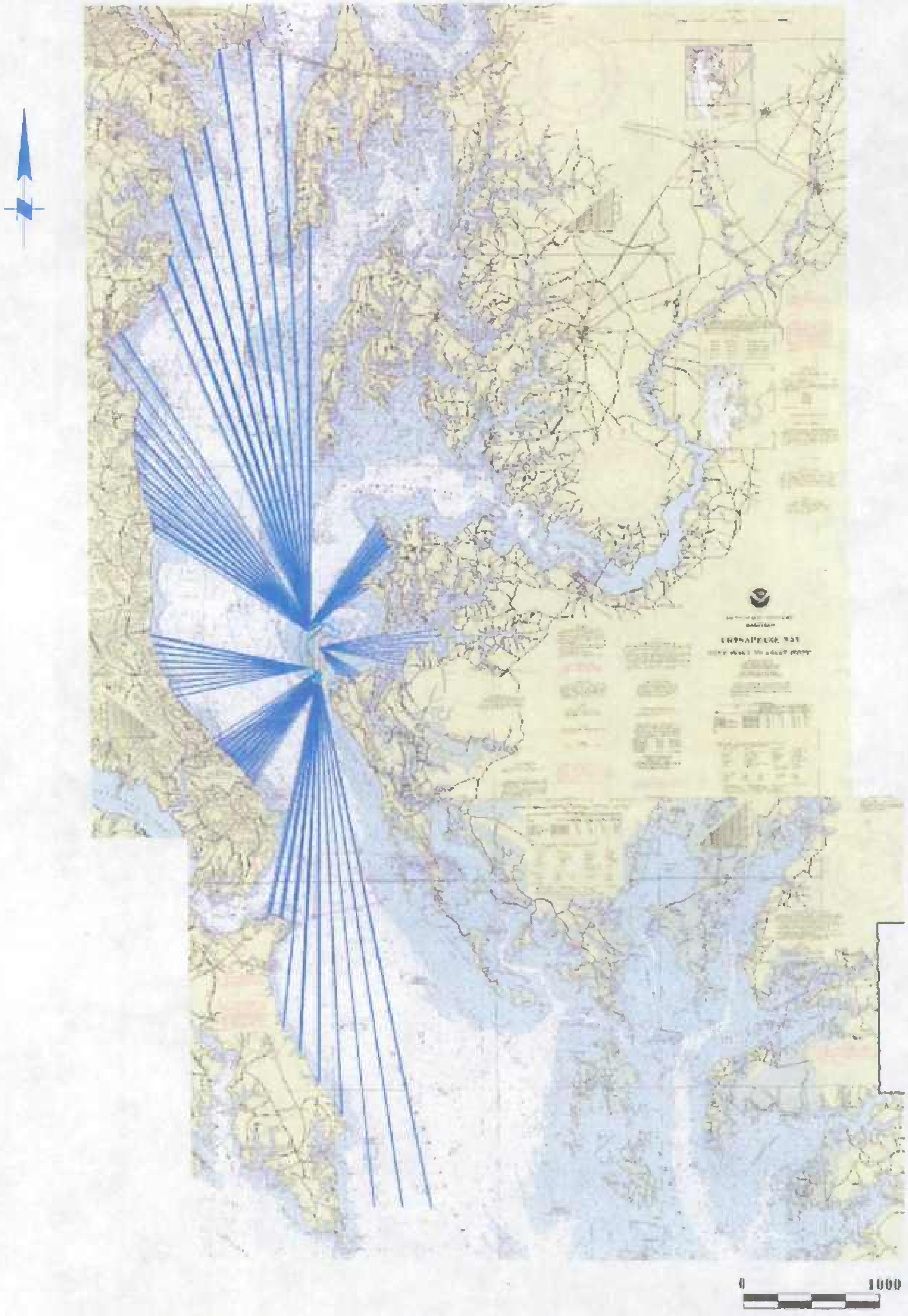

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FIGURE 2-8
RADIALLY AVERAGED FETCHES
ALL ALIGNMENTS

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FIGURE 2-9
RADIALLY AVERAGED FETCHES
ALIGNMENT 1

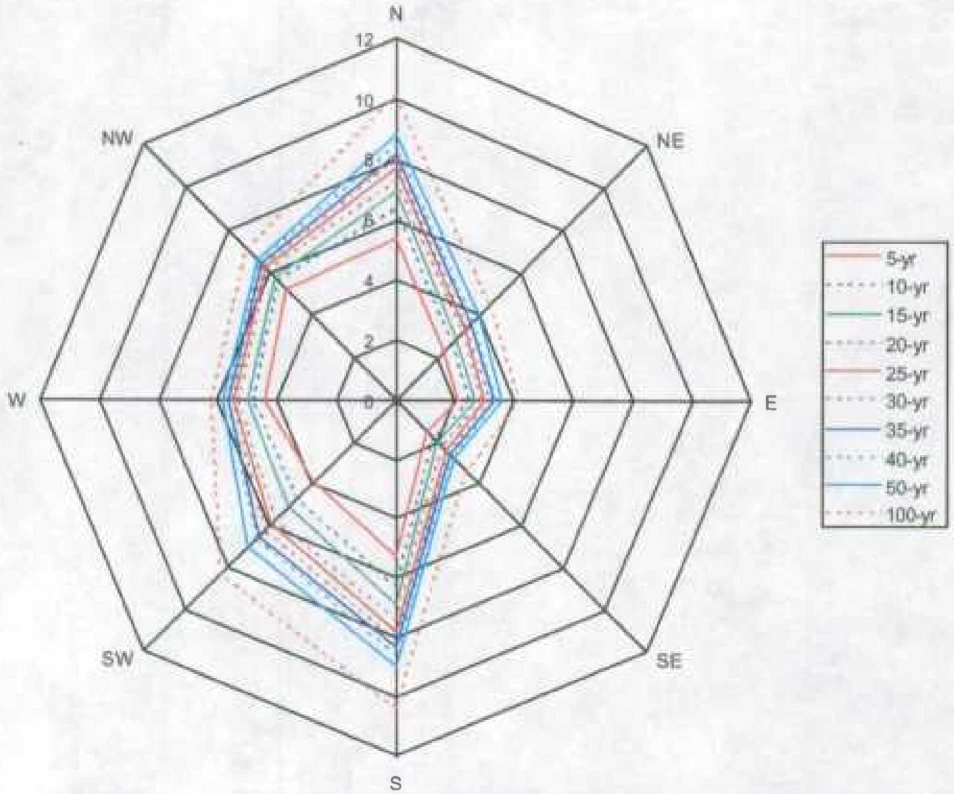

Figure 2-10. Offshore Significant Wave Heights (ft) for James Island Alignment 1.

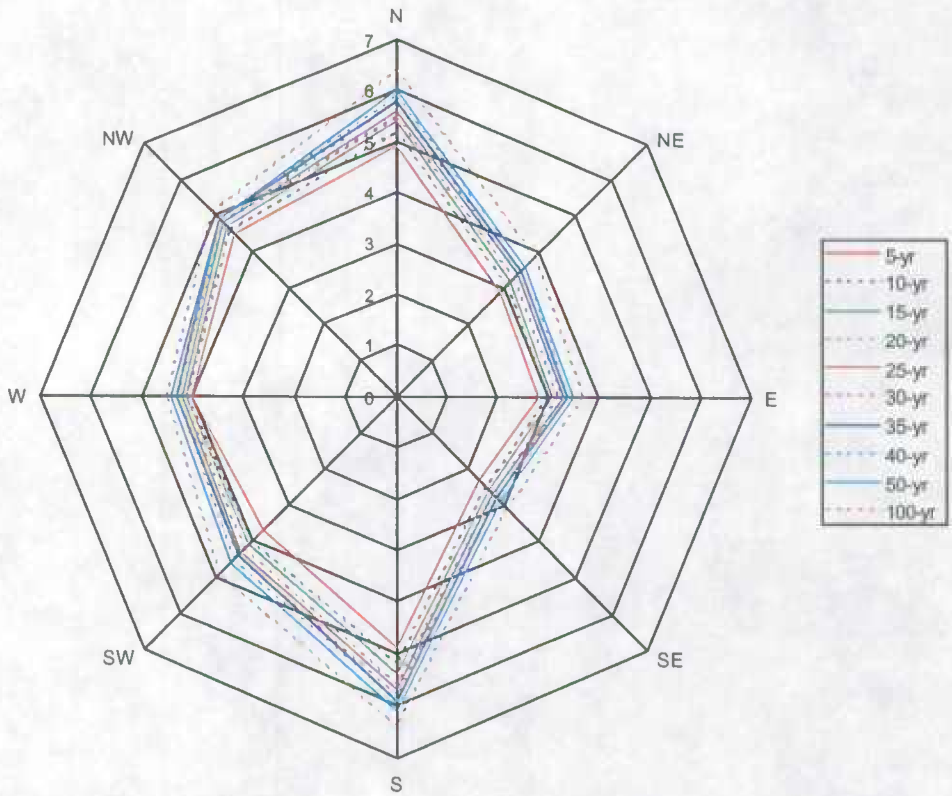

Figure 2-11. Peak Spectral Wave Periods (sec) for James Island Alignment 1.

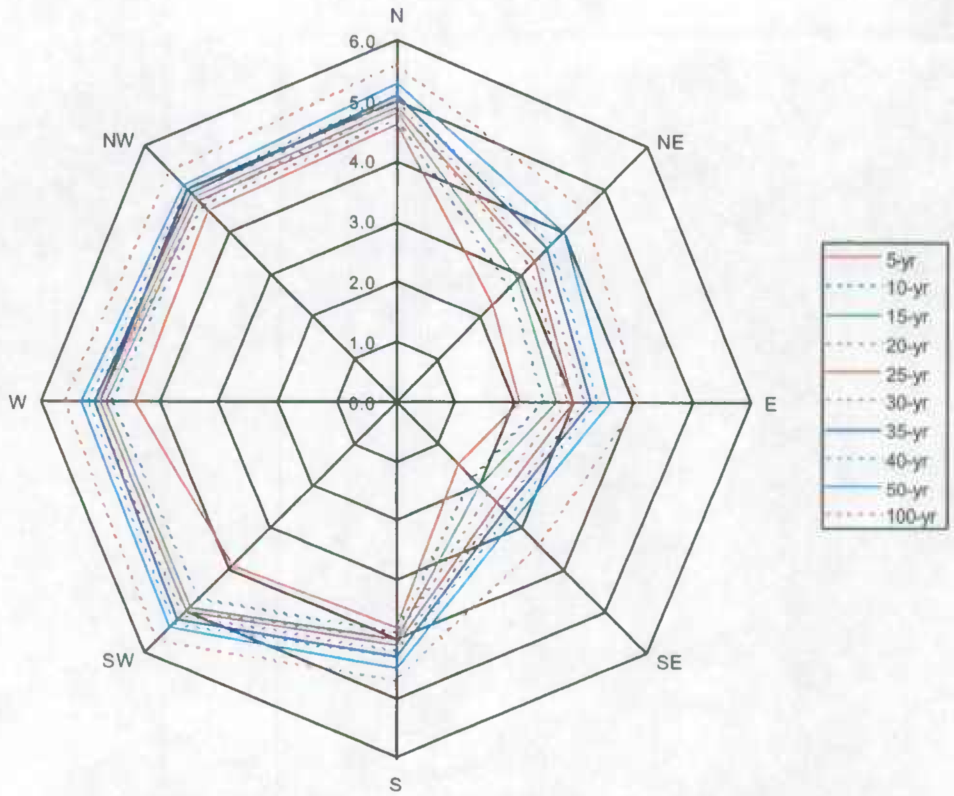

Figure 2-12. Nearshore Significant Wave Heights (ft) for James Island Alignment 1.

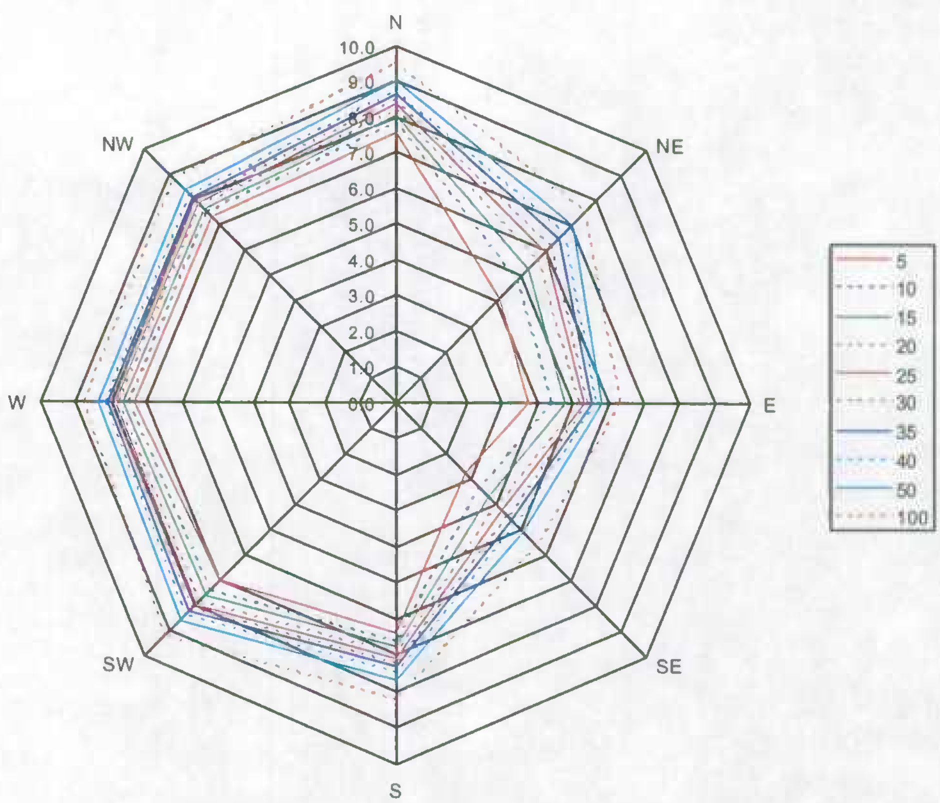

Figure 2-13. Nearshore Maximum Wave Heights (ft) for James Island Alignment 1.

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FIGURE 2-14
RADIALLY AVERAGED FETCHES
ALIGNMENT 2

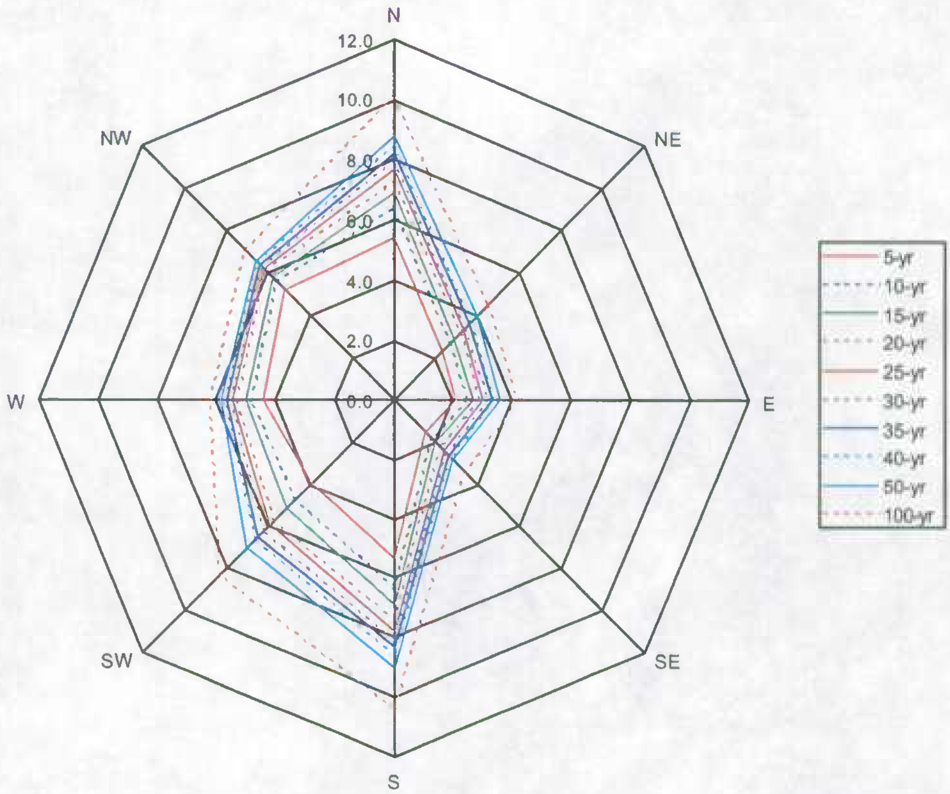

Figure 2-15. Offshore Significant Wave Heights (ft) for James Island Alignment 2.

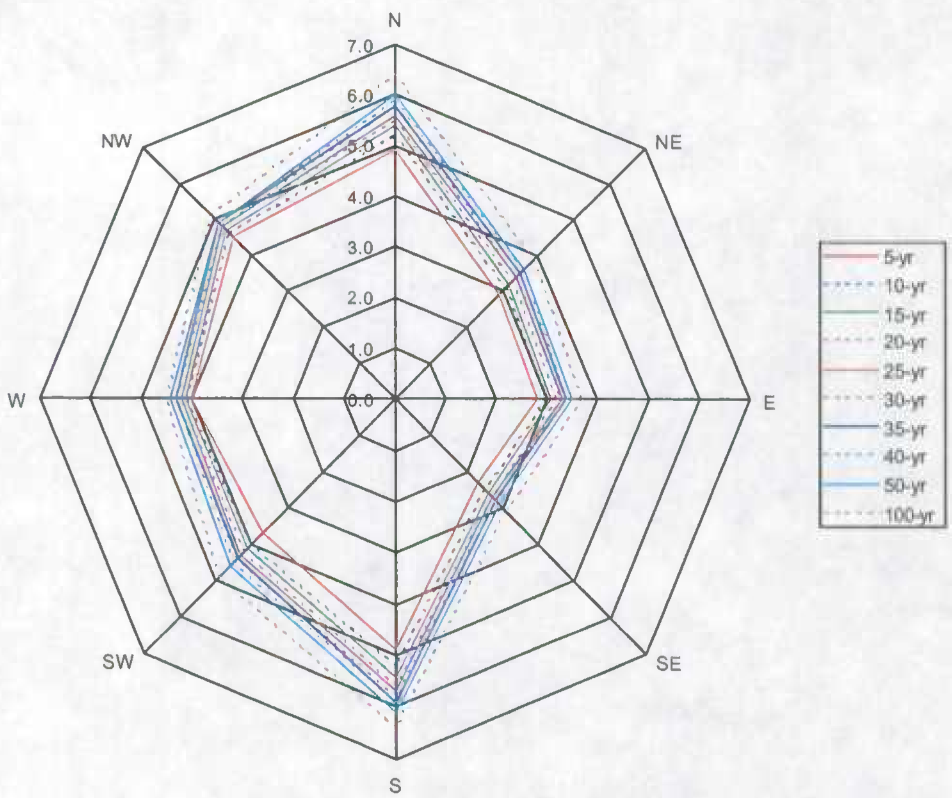

Figure 2-16. Peak Spectral Wave Periods (sec) for James Island Alignment 2.

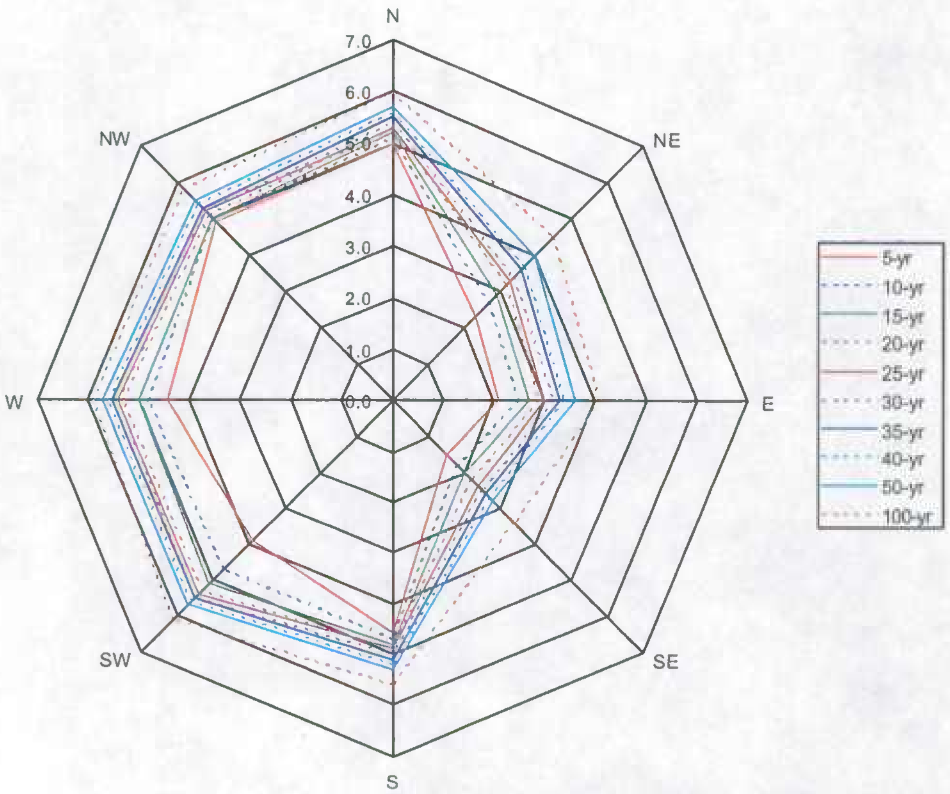

Figure 2-17. Nearshore Significant Wave Heights (ft) for James Island Alignment 2.

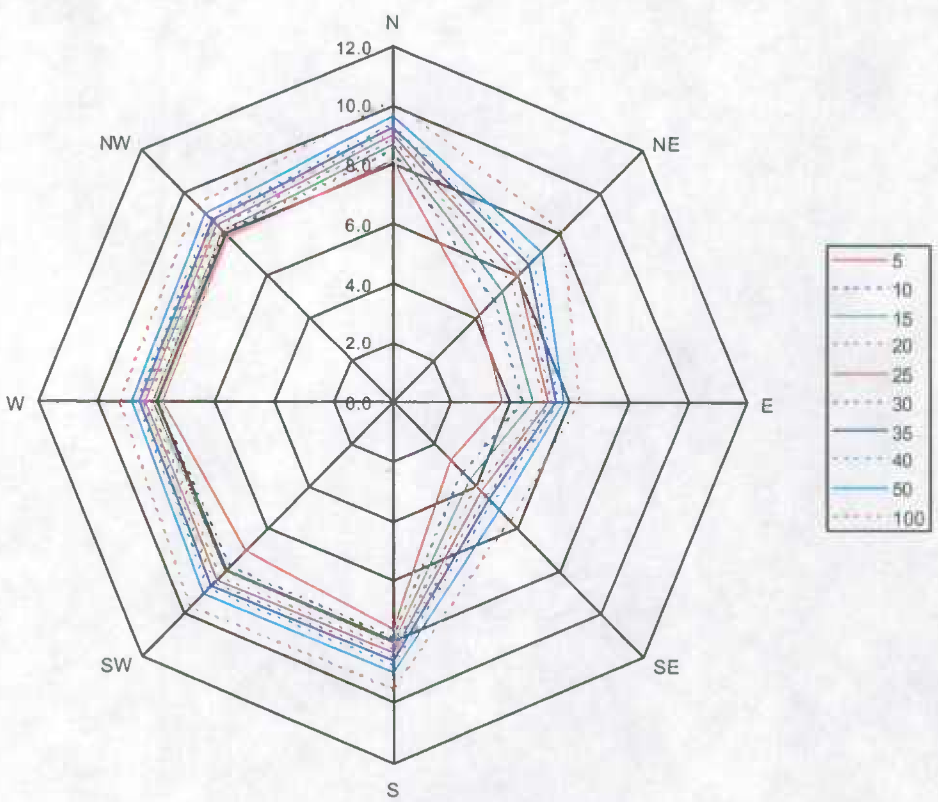

Figure 2-18. Nearshore Maximum Wave Heights (ft) for James Island Alignment 2.

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FIGURE 2-19
RADIALLY AVERAGED FETCHES
ALIGNMENT 3

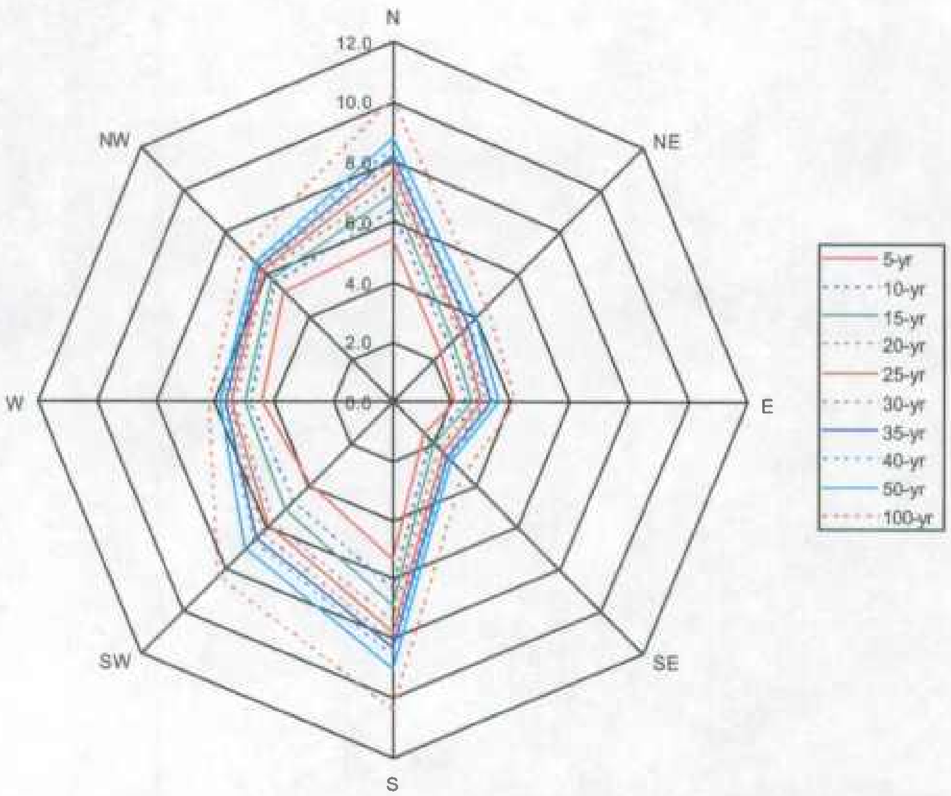

Figure 2-20. Offshore Significant Wave Heights (ft) for James Island Alignment 3.

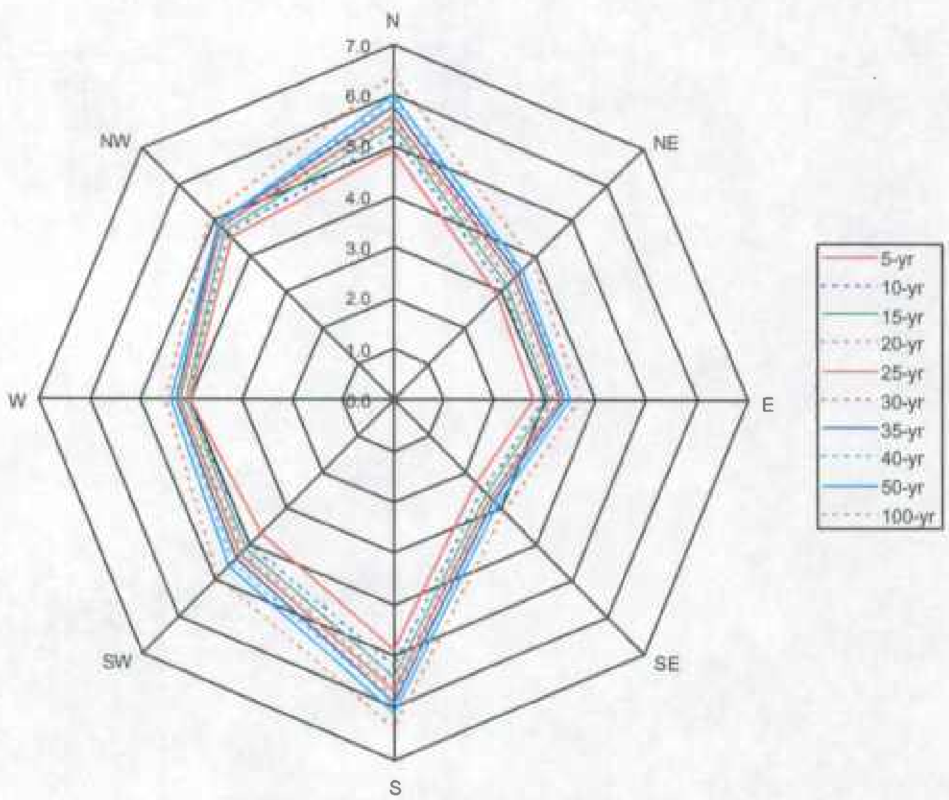

Figure 2-21. Peak Spectral Wave Periods (sec) for James Island Alignment 3.

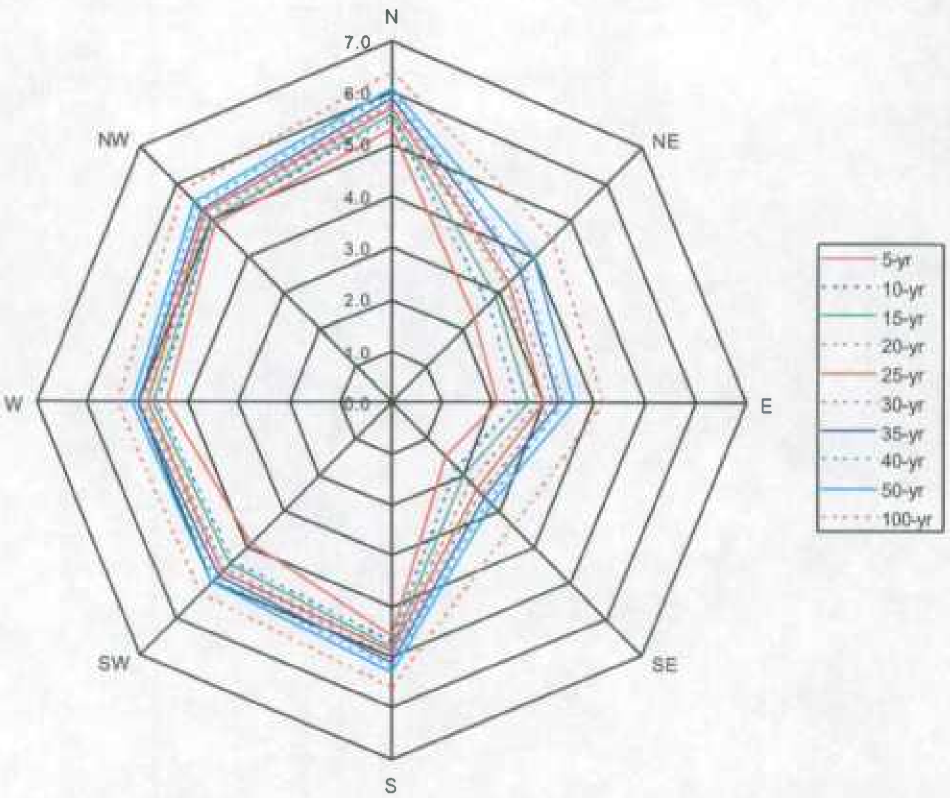

Figure 2-22. Nearshore Significant Wave Heights (ft) for James Island Alignment 3.

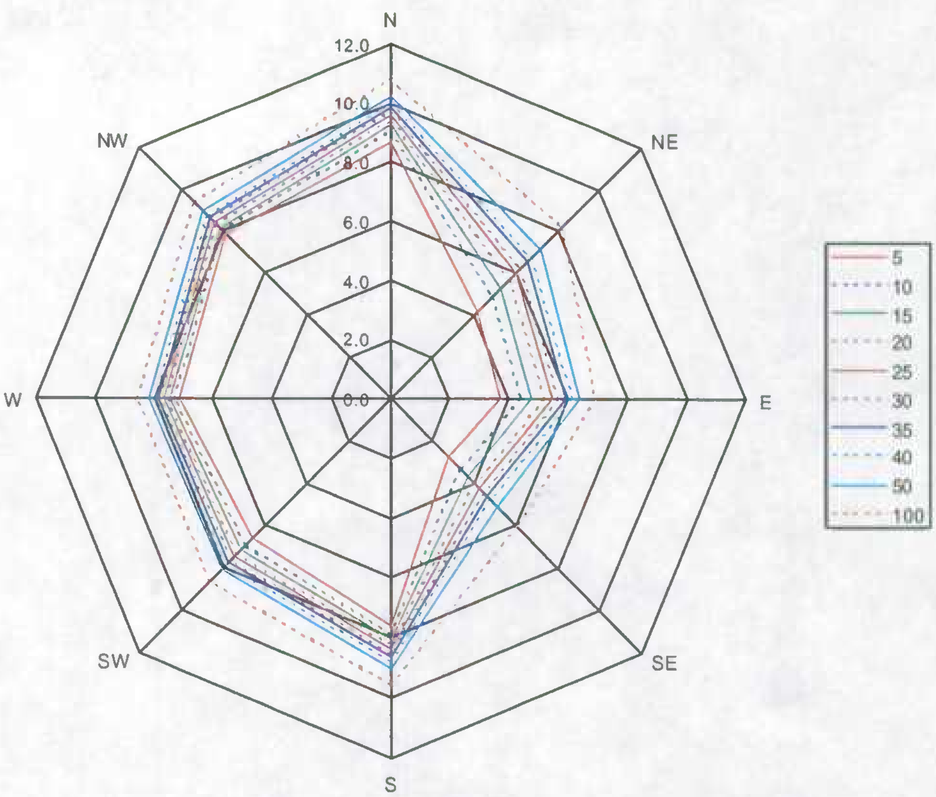

Figure 2-23. Nearshore Maximum Wave Heights (ft) for James Island Alignment 3.

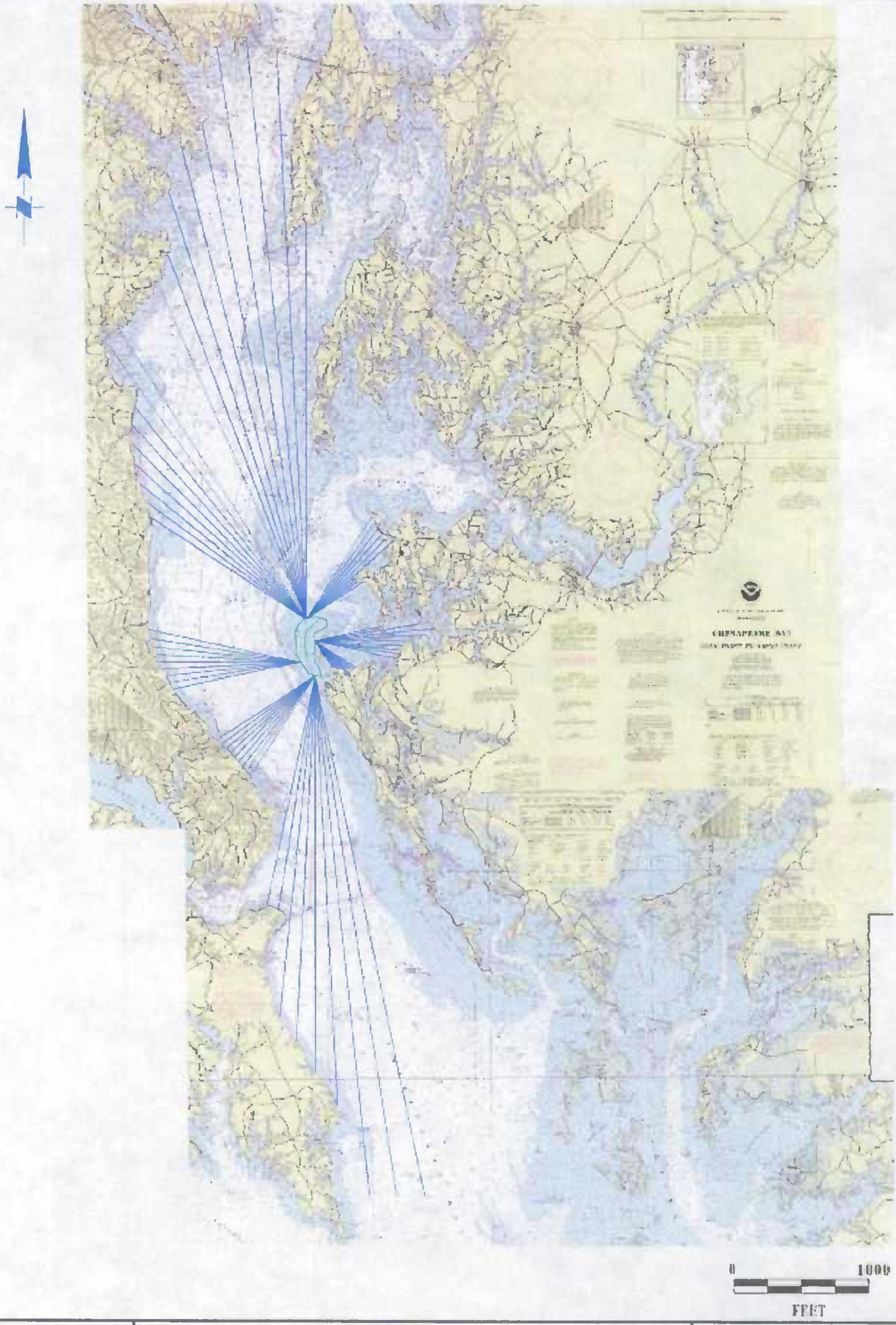

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FIGURE 2-24
RADIALLY AVERAGED FETCHES
ALIGNMENT 4

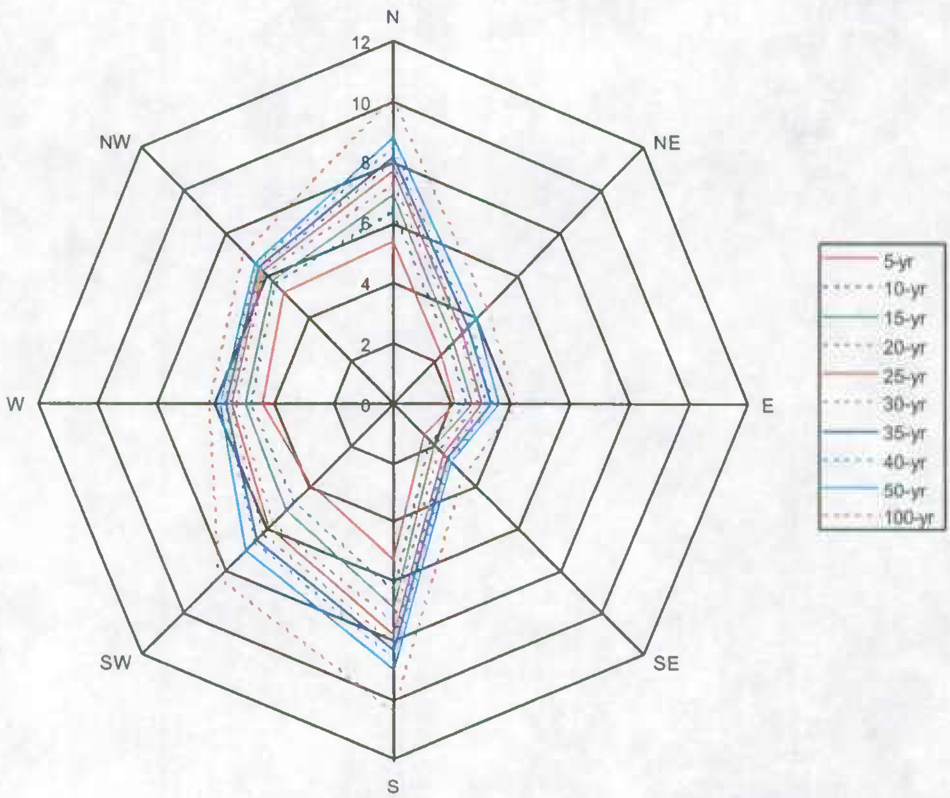

Figure 2-25. Offshore Significant Wave Heights (ft) for James Island Alignment 4.

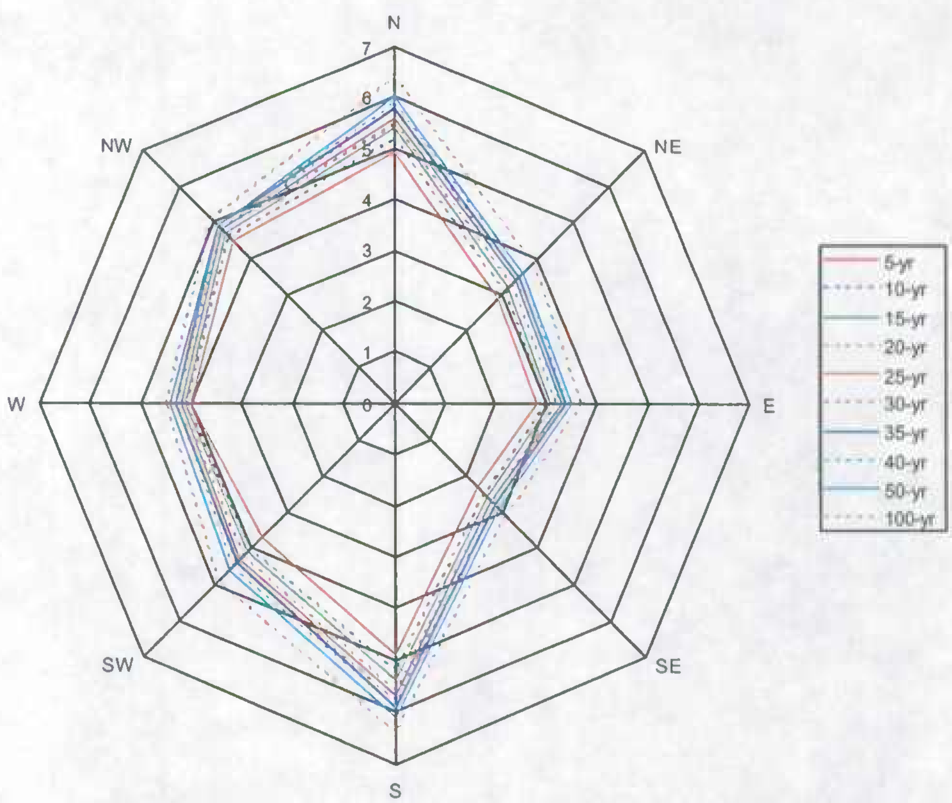

Figure 2-26. Peak Spectral Wave Periods (sec) for James Island Alignment 4.

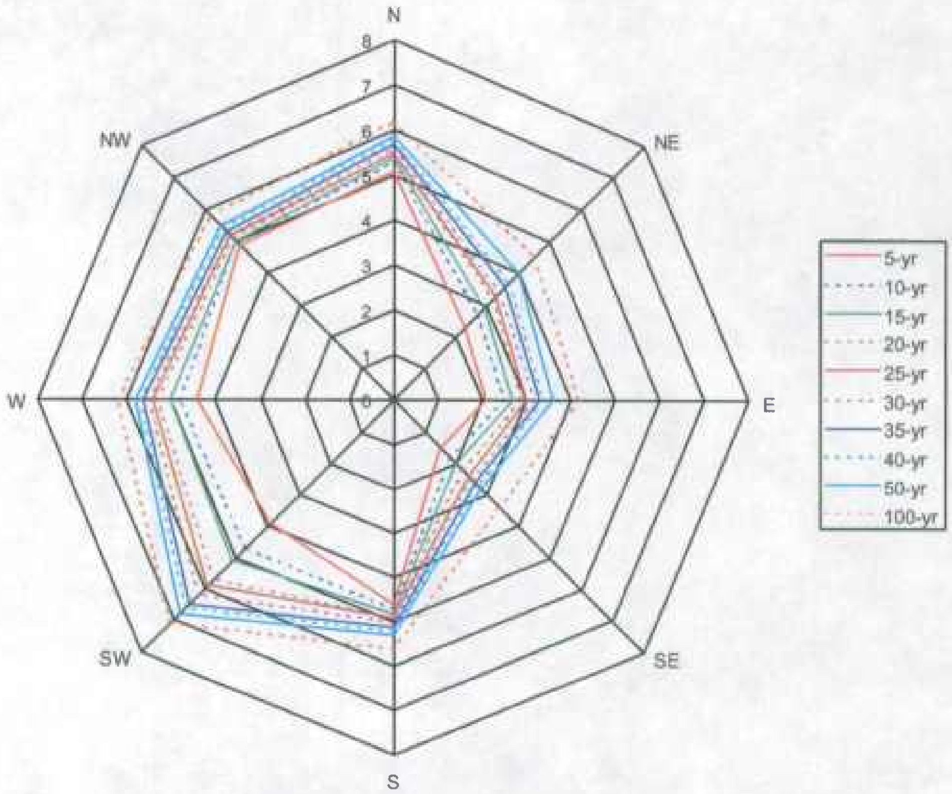

Figure 2-27. Nearshore Significant Wave Heights (ft) for James Island Alignment 4.

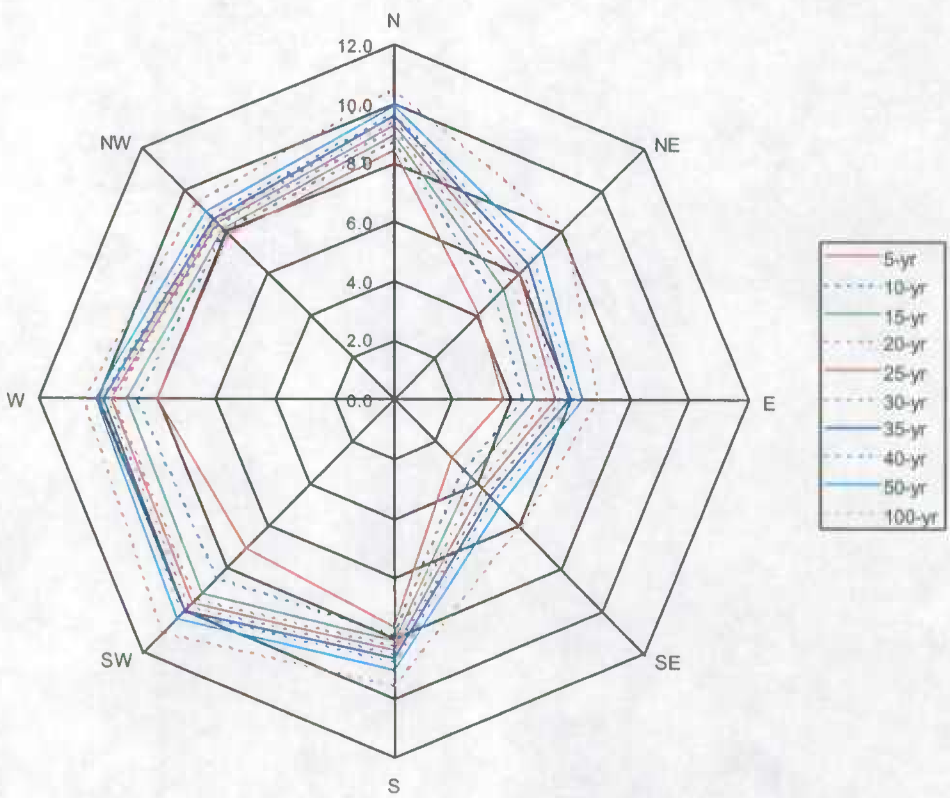

Figure 2-28. Nearshore Maximum Wave Heights (ft) for James Island Alignment 4.

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FIGURE 2-29
RADIALLY AVERAGED
FETCHES
ALIGNMENT 5

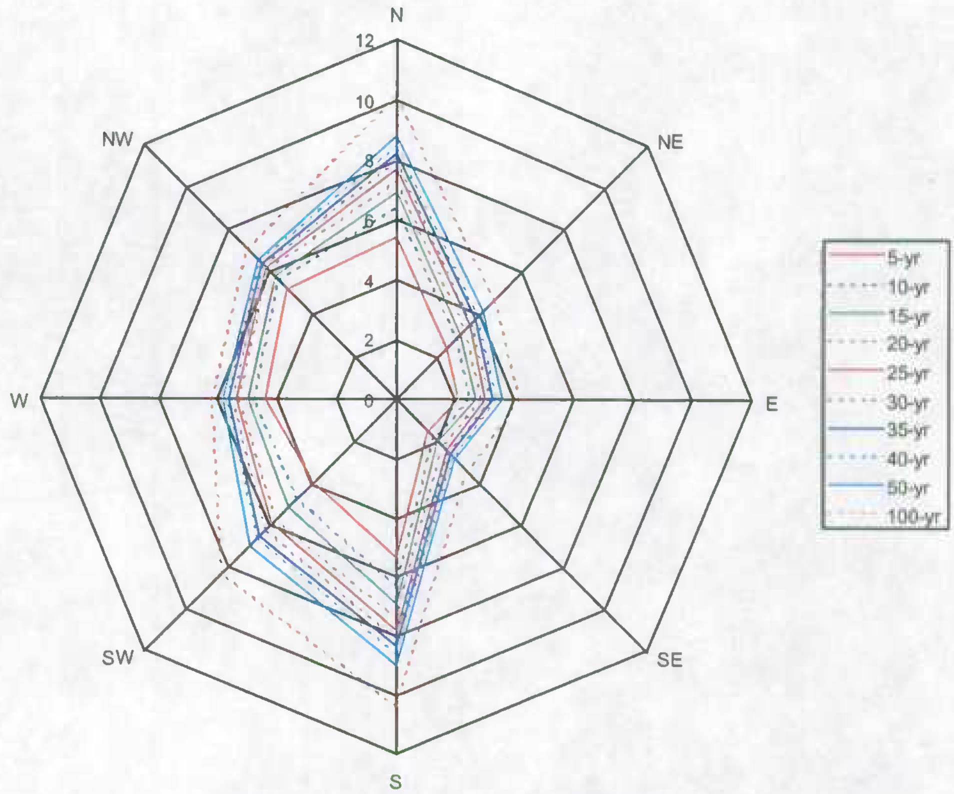


Figure 2-30. Offshore Significant Wave Heights (ft) for James Island Alignment 5.

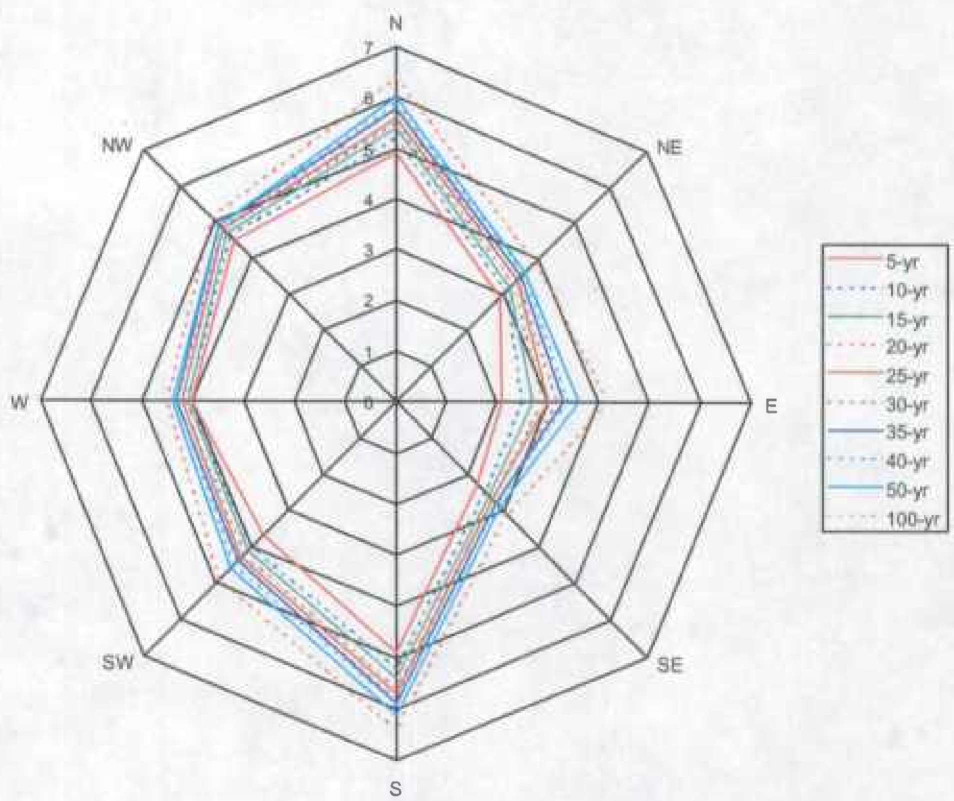


Figure 2-31. Peak Spectral Wave Periods (sec) for James Island Alignment 5.

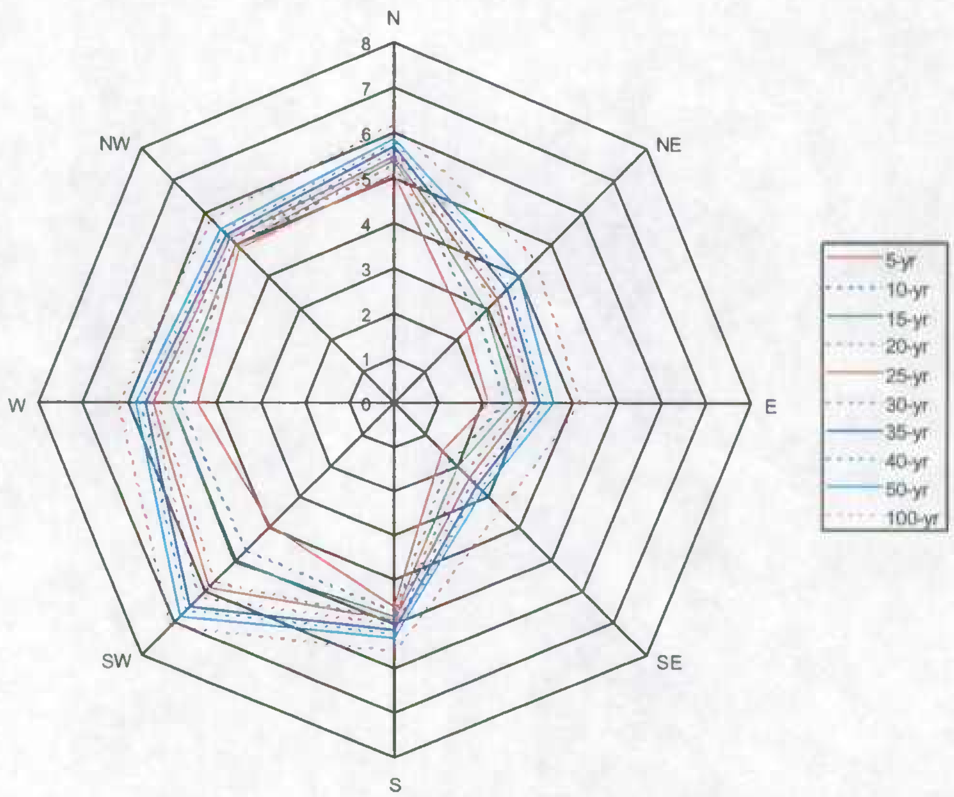


Figure 2-32. Nearshore Significant Wave Heights (ft) for James Island Alignment 5.

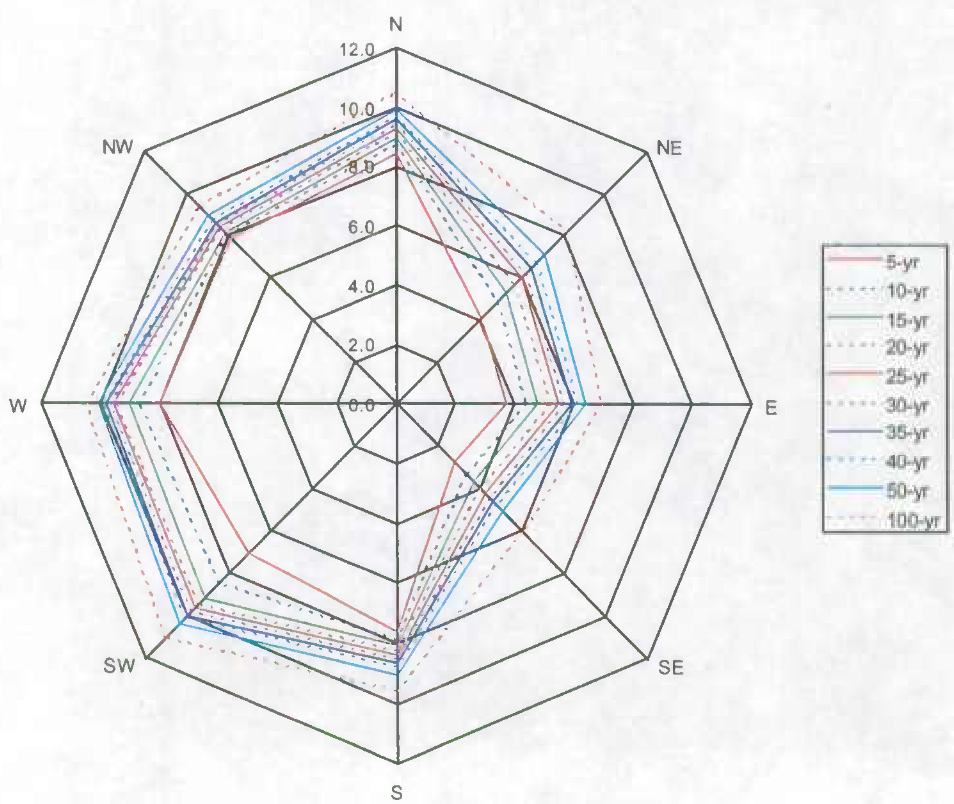


Figure 2-33. Nearshore Maximum Wave Heights (ft) for James Island Alignment 5.

3. DIKE CONSTRUCTION

3.1 Introduction

The principal components of a coastal protection dike include:

- Toe Protection
- Protective Revetment
- Berm (if included)
- Upper Slope
- Crest Area and Roadway
- Dike Core

Toe protection is normally an integral part of the revetment structure and is designed to prevent that structural component from undermining as a result of wave and/or current-induced scour. The protective revetment serves to hold the dike core in place and is often comprised of several layers of rock armoring. A berm may or may not be included in the dike cross section. Where included, a berm can be used to limit wave runup and overtopping. The berm can also be used to minimize the armoring requirements for the revetment and upper slope of the dike. Roadways are often included on dikes in order to provide access for operations and repairs to the dikes.

The dike geometry used for this preliminary study is comprised of toe protection, a rubble mound revetment (i.e. the side slope), a horizontal crest with a crushed stone roadway and a core constructed of sand. One of the more important variables of the dike design is the side slope which, together with the crest height, is generally dictated by soil conditions and dike construction methodologies. Based on the analyses performed for prior projects, and the geotechnical analysis performed for this project, the dike design has been determined to have an outer slope of three horizontal to one vertical (3:1) and an inner side slope of five horizontal to one vertical (5:1).

3.2 Dike Design Life

The design life selected for the containment dikes is an important factor in the overall planning. It should be noted that project life for dike design is different than the life capacity of the site for storing dredged material. The former pertains to the life expectancy and costs of the containment dikes and is treated in this section of the report whereas the latter pertains to the period of time it takes to fill the dredged material placement site.

Previously, USACE would stipulate a project life of 50 years (ER-1110-2-1407 "Hydraulic Design of Coastal Shore Protection Projects"). This has now been superseded by the revised ER-1110-2-1407 (November 1990) which dictates that a fuller range of alternatives be studied to account for differences in cost of repair, periodic replacements and rehabilitation. The 50-year project life is consistent with the nature of routine coastal and hydraulic engineering projects, which are designed to protect large areas of rural and urban infrastructure against flooding and/or wave-induced damages. Furthermore, such projects are normally justified on the basis of a rigorous and codified economic analysis, which assures that the project benefits exceed project costs. A practical means for selecting the project design life for James Island could be on the basis of economics (i.e. project costs and cost effectiveness). This approach was used for the design of Phases 1 and 2 of Poplar Island Environmental Restoration Project (PIERP) dikes (GBA-M&N JV 1995), and has been used in selecting the design return periods for this project.

3.3 Dike Design Values

The dikes must be designed for a given level of hydrodynamic design conditions including winds, waves, water levels, and currents. Design conditions can be stipulated in terms of levels of risk and/or in terms of statistical return period. These two factors are related to one another and the project life through the following formula:

$$R = 1 - \left(1 - \frac{1}{RP}\right)^{L}$$

Where:

R = risk or probability that a given condition will be equaled or exceeded

L = project life in years

RP = return period in years

The previous USACE criteria stipulate that a project should be designed for an event that has a 50% risk during a 50 year project life. Manipulation of the above formula will show that these criteria correspond to a return period of 73 years. Stated simply, the return period is the average time intervals between events of a similar magnitude. For example, a 73-year design wave would be a wave that occurs an average of once every 73 years. The optimization analysis performed for Phases 1 and 2 of the PIERP indicated that a 35-year return period is optimal for design of the dikes. That design return period is applied to the James Island Restoration Project.

3.4 Geotechnical Factors

The main geotechnical factors that should be evaluated in the design of the habitat restoration dikes (Pilarczk 1990) are:

- Macro-instability of slopes due to failure along circular or straight sliding surfaces
- Settlements and horizontal deformations due to the self weight of the structure
- Micro-instability of slopes caused by groundwater seepage out of the slope face
- Piping or internal erosion due to seepage flow underneath the structure
- Liquefaction caused by erosion (flow down the side slopes) or by cyclic loading wave actions or earthquakes)
- Erosion of revetments at the outer slopes (or underwater slopes) due to instable filters or local failure of top layer elements

The phenomena most germane to the overall planning of the dike designs are: (1) slope stability which dictates maximum allowable combinations of side slopes and structure heights and (2) settlement which influences the initial and final crest elevation of the dike. The geotechnical assessment indicates that improvements to the foundation may be needed in some areas to construct dikes. For this report it is assumed that the foundation has been strengthened as required to permit an outer structure slope of three horizontal to one vertical (3:1). Wave runup, overtopping, armor stone sizing and toe scour protection are evaluated for a 3:1 side slope. It is noted that this side slope is the same as that used for the majority of the dike at the Hart-Miller Island Dredged Material Containment Facility (HMI DMCF) and the design of Phases 1 and 2 for the PIERP.

3.5 Dike Height - Wave Runup and Overtopping

One of the primary functions of the containment dikes is to protect the interior of the diked placement area against the adverse effects of high water and waves. If a high level of protection is required, the structure should have a height well above the maximum level of wave runup during storm surges. Typically, this requires setting high crest elevations for the structure. However, if some overtopping is allowed based on the nature of the site (i.e., wetlands), the design requirement can be evaluated in terms of allowable overtopping. The design then is based on maintaining the structural integrity of the dikes themselves with minimal concern for protecting the interior.

The level of protection against high water and wave attack has been defined as the return period of the storm event that balances initial dike construction capital costs with long-term operations and maintenance costs needed to repair the dike as a result of destruction from wave runup and/or overtopping waves. Wave runup, and more importantly, overtopping computations allow an objective means for evaluating the level of protection (i.e. allowable overtopping) offered by various dike height and armor protection combinations. In addition, wave overtopping computations provide a rational means for evaluating the relative risk of dike breaching and subsequent failure.

Wave runup is commonly evaluated on the basis of the composite-slope runup method outlined in the Shore Protection Manual (SPM) (USACE 1984). This approach has been critically reviewed by the Federal Emergency Management Agency (FEMA) (1988) who found that the composite slope method provides a valid method for estimating the *mean* runup value in random waves but was lacking in its ability to predict *extreme* values of wave runup. The mean runup values computed using the FEMA composite-slope runup model are generally on the order of 2 to 4 ft above the still water level under extreme conditions (e.g. 50 to 100 year storms). Low or insignificant wave overtopping discharge values are normally computed on the basis of the mean wave runup values.

Dutch engineers have long appreciated the need to consider wave runup levels higher than the mean values in design applications and have generally used the 2% exceedence runup value to select the heights of dunes and coastal dikes. Van der Meer (1992) published the following formulae for computing the 2% runup for seawalls and dikes:

$$R_{2\%} = 1.5\gamma_f \gamma_h \xi_p$$

$$Maximum = 3.0\gamma_f \gamma_h$$

$$\xi_p = \frac{\tan\alpha}{\sqrt{S_p}}$$

$$S_p = \frac{H_s}{\frac{g}{2\pi} T_p^{\,2}}$$

Where:

$R_{2\%}$ = 2% wave runup (wave runup exceeded only 2% of the time during a storm) (unitless)

γ = influence factor for roughness (unitless)

γ_h = influence factor for shallow water (unitless)

ξ_p = breaker parameter (surf similarity parameter) based on equivalent slope (unitless)

Maximum = the absolute maximum value of $R_{2\%}$

α = angle of beach and or structure slope

S_p = wave steepness (unitless)

H_s = significant wave height, average of highest one-third (ft)

g = acceleration due to gravity (ft/sec^2)

T_p = peak spectral wave period (sec)

Van der Meer's formulae are based on an extensive series of physical model tests including several full scale tests for 3:1 slopes.

The influence of roughness based on Van der Meer (1992) is summarized as follows:

Surface Covering	Influence Factor (γ_f)
One Layer of Rock	0.55-0.60
Two or More Rock Layers	0.50 - 0.55

A value of 0.55 was used for the present work, to provide the most conservative estimate for dikes with two rock layers.

When a dike is located in shallow water, the higher waves will break before they reach the structure. In that case, the distribution of wave heights at the toe of the structure must take wave breaking into account. The influence factor, γ_f, for shallow water can be determined by the following formula:

$$\gamma_h = \frac{H_{2\%}}{1.4\,H_s}$$

For a gentle foreshore slope of 1:100 the following formula can be used:

$$\gamma_h = 1 - 0.03\left[4 - \frac{h}{H_s}\right] \qquad for\ 1 \leq h/\,H_s \leq 4$$

Finally, the mean runup can be estimated from the 2% runup using the following formula which assumes a Rayleigh distribution:

$$\gamma_h = 1 \qquad for\ h/\,H_S \geq 4$$

While wave runup is an important overall indicator of the protection offered by coastal dikes, wave overtopping is judged to be a more objective and rationale method for estimating level of wave protection for the present work. Van der Meer (1992) presents the following formula for estimating the mean wave overtopping on coastal structures subject to random waves:

$$\frac{q}{\sqrt{gH_s^{\;3}}} = 8\times10^{-5}\exp\left(3.1\frac{R_{u2\%}-R_c}{H_s}\right)$$

Where:

q = mean wave overtopping discharge per unit width (liter/sec·m)

R_c = dike crest freeboard (height of structure above still water) (ft)

$R_{u2\%}$ = 2% wave runup (ft)

The reliability of the above equation can be given by assuming that $log(q/\sqrt{gH^3_s})$ has a normal distribution with a variation coefficient (the ratio of the standard deviation to the mean value) of 0.11. Reliability bands can then be calculated for various practical values of mean overtopping discharges. The 90% confidence bands have been used for the purposes of this report.

The above overtopping formula provides a means for computing wave overtopping on dikes of various geometries (i.e. structure slopes, slope breaks and crest elevations). In order to evaluate the level of protection offered by a given dike configuration, it is necessary to establish limiting values of allowable overtopping. Critical or allowable overtopping discharges have been published by the United Kingdom (UK) Construction Industry Research and Information Association (CIRIA) and the Netherlands Centre for Civil Engineering Research and Codes (CUR) (CIRIA/CUR 1991). Similar values have also been published by Goda (1985). The Goda allowable overtopping values have been used in this study and are summarized below:

Structure Type	**Surface Armoring**	**Overtopping Rate (Liters/m·s)**
Type I: Coastal Dike	Concrete on front slope, soil on crown and back slope	5
Type II: Coastal Dike	Concrete on front slope and crown, soil on back slope	20
Type III: Coastal Dike	Concrete on front slope, crown and back	50
Type IV: Revetment	No pavement on ground	50
Type V: Revetment	Pavement on ground	200

Overtopping computations from Van der Meer's formula were used to develop required crest elevations for construction of a dike with no armor stone on the crest or back slope. The results for dikes having a 3:1 side slope are summarized in Tables 3-1 through 3-5 and the corresponding polar plots in Figures 3-1 through 3-5 for Alignments 1, 2, 3, 4 and 5, respectively.

Generally, required crest elevations for James Island are highest for dikes exposed to waves from the north. For a 5-year storm the required crest elevations for waves from the north are 8.2 ft, 8.5 ft, 8.9 ft, 8.7 ft and 8.7 ft for Alignments 1, 2, 3, 4 and 5, respectively. For a 35-year storm the required crest elevations for waves from the north are 10.7 ft, 11.2 ft, 11.6 ft, 11.4 ft and 11.4 ft for Alignments 1, 2, 3, 4 and 5, respectively. For a 100-year storm the required crest elevations for waves from the north are 12.9 ft, 13.5 ft, 14.0 ft, 13.7 ft and 13.7 ft for Alignments 1, 2, 3, 4 and 5, respectively. The lowest required crest elevations for James Island are for a dike exposed to waves from the east. The crest height for all five alignments for the 5-year storm is 4.5 ft. For the 35-year storm, required crest heights are 6.6 ft for Alignments 1, 3, 4 and 5, and 6.5 ft for Alignment 2. The required crest heights for the 100-year storm are 8.5 ft for Alignments 1, 3, 4, and 5 and 8.4 ft for Alignment 2.

Table 3-1 Required Crest Height (ft) James Island – Alignment 1

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.2	4.7	4.5	3.9	7.4	6.5	7.3	8.0
10	8.8	5.3	5.0	4.3	8.0	7.4	7.9	8.4
15	9.3	5.7	5.4	4.6	8.3	7.8	8.3	8.7
20	9.7	6.1	5.8	4.9	8.6	8.2	8.8	9.0
25	10.0	6.4	6.0	5.2	8.9	8.5	9.0	9.3
30	10.4	6.7	6.3	5.4	9.1	8.8	9.3	9.5
35	10.7	7.1	6.6	5.7	9.4	9.1	9.6	9.8
40	11.0	7.3	6.9	5.9	9.7	9.4	9.8	10.0
50	11.6	7.9	7.3	6.4	10.2	9.9	10.3	10.5
100	12.9	9.2	8.5	7.5	11.3	11.2	11.5	11.6

Table 3-2 Required Crest Height (ft) James Island – Alignment 2

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.5	4.7	4.5	3.9	8.1	6.5	7.2	8.0
10	9.2	5.3	5.0	4.3	8.8	7.5	7.7	8.4
15	9.7	5.7	5.3	4.6	9.3	8.1	8.1	8.7
20	10.1	6.1	5.7	4.9	9.7	8.5	8.5	9.0
25	10.5	6.4	6.0	5.2	10.1	8.9	8.8	9.3
30	10.8	6.7	6.2	5.4	10.4	9.2	9.0	9.5
35	11.2	7.1	6.5	5.6	10.8	9.5	9.3	9.8
40	11.5	7.3	6.8	5.9	11.1	9.7	9.5	10.0
50	12.1	7.9	7.2	6.3	11.7	10.3	9.9	10.5
100	13.5	9.1	8.4	7.4	12.9	11.6	11.0	11.6

Table 3-3 Required Crest Height (ft) James Island – Alignment 3

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.9	4.7	4.5	3.9	8.1	6.4	7.0	8.0
10	9.6	5.3	5.0	4.3	8.8	7.1	7.4	8.4
15	10.1	5.7	5.4	4.6	9.3	7.5	7.7	8.7
20	10.5	6.1	5.8	4.9	9.7	7.9	8.0	9.0
25	10.9	6.4	6.0	5.2	10.1	8.2	8.3	9.3
30	11.3	6.7	6.3	5.4	10.4	8.5	8.5	9.5
35	11.6	7.1	6.6	5.7	10.8	8.8	8.8	9.8
40	11.9	7.3	6.9	5.9	11.1	9.0	9.0	10.0
50	12.5	7.9	7.3	6.4	11.7	9.6	9.4	10.5
100	14.0	9.2	8.5	7.5	12.9	10.8	10.4	11.6

Table 3-4 Required Crest Height (ft) James Island – Alignment 4

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.7	4.7	4.5	3.9	8.1	6.6	7.3	8.0
10	9.4	5.3	5.0	4.3	8.8	7.7	7.9	8.4
15	9.9	5.7	5.4	4.6	9.3	8.3	8.3	8.7
20	10.3	6.1	5.8	4.9	9.7	9.1	8.8	9.0
25	10.7	6.4	6.0	5.2	10.1	9.5	9.0	9.3
30	11.1	6.7	6.3	5.4	10.4	10.0	9.3	9.5
35	11.4	7.1	6.6	5.7	10.8	10.4	9.6	9.8
40	11.7	7.3	6.9	5.9	11.1	10.8	9.8	10.0
50	12.3	7.9	7.3	6.4	11.7	11.4	10.3	10.5
100	13.7	9.2	8.5	7.5	12.9	12.7	11.5	11.6

Table 3-5 Required Crest Height (ft) James Island – Alignment 5

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	8.7	4.7	4.5	3.9	8.1	6.6	7.3	8.0
10	9.4	5.3	5.0	4.3	8.8	7.7	7.9	8.4
15	9.9	5.7	5.4	4.6	9.3	8.3	8.3	8.7
20	10.3	6.1	5.8	4.9	9.7	9.1	8.8	9.0
25	10.7	6.4	6.0	5.2	10.1	9.5	9.0	9.3
30	11.1	6.7	6.3	5.4	10.4	10.0	9.3	9.5
35	11.4	7.1	6.6	5.7	10.8	10.4	9.6	9.8
40	11.7	7.3	6.9	5.9	11.1	10.8	9.8	10.0
50	12.3	7.9	7.3	6.4	11.7	11.4	10.3	10.5
100	13.7	9.2	8.5	7.5	12.9	12.7	11.5	11.6

3.6 Armor Stone

There are a number of methodologies available for determining armor stone requirements for dike revetments subject to wave attack. A commonly used method is based on the Hudson equation published in the SPM (USACE 1984):

$$W = \frac{\gamma_r H^3}{K_D (S_r - 1)^3 \cot(\theta)}$$

Where:

W = weight of armor stone (lbs)

γ_r = unit weight of the armor rock (taken as 165 lb/ft^3)

H = wave height to which the structure is exposed (ft)

K_D = stability coefficient (unitless)

S_r = γ_r / γ_w (unitless)

γ_w = unit weight of water (taken as 64 lb/ft^3)

θ = angle of structure slope

The dikes at James Island will be located in a combination of relatively deep and relatively shallow water (range of –12 to –3 ft MLLW), and will be exposed to a wave spectrum characterized by breaking and non-breaking waves. The wave height used in the above equation depends on whether one is evaluating breaking or non-breaking waves. According to the SPM (USACE 1984), an H_{10} wave height, which is equal to 1.27 times the significant wave height (H_s), is used for the non-breaking wave height while the maximum depth limited wave height is used for breaking waves.

Previous studies have shown that use of the Hudson formula results in oversized armor stone, and a more appropriate method is to use procedures published by Van der Meer (1988). Van der Meer's equations for sizing armor stone subject to shallow water random waves are as follows:

For Plunging Waves:

$$\frac{H_{2\%}}{\Delta} = 8.7 \; P^{0.18} \left(\frac{S}{\sqrt{N}}\right)^{0.2} \xi_m^{-0.5}$$

For Surging Waves:

$$\frac{H_{2\%}}{\Delta} D_{n50} = 1.4 \, P^{-0.13} \left(\frac{S}{\sqrt{N}}\right)^{0.2} \xi_m^{P}$$

The waves are of the surging types when:

$$\xi_{mc} \geq 6.2 \, P^{0.31} \sqrt{\left(\tan\theta^{1/(P+0.5)}\right)}$$

Where:

$H_{2\%}$ = two percent exceedence wave height (ft)

Δ = Sr - 1

D_{n50} = mean nominal diameter of the stone = $(W/S_r)^{1/3}$ (ft)

S = structural damage level taken as 2 for 0-5% damage (unitless)

N = number of waves in the storm (a value of 7000 was used) (unitless)

P = structure permeability (taken as 0.1 which is typical of a revetment structure with an armor layer, under or filter layer and an impermeable core) (unitless)

ξ_m = surf similarity parameter (unitless)

The surf similarity parameter is defined as a function of angle structure slope, θ, significant wave height, H_s, and peak spectral wave period, T_p:

$$\xi_m = \frac{\tan(\theta)}{\sqrt{\dfrac{2\pi H_s}{gT_p^{\ 2}}}}$$

Where:

H_s = significant wave height

T_p = peak spectral wave period

The methodology presented by Van der Meer is judged to be most applicable because it is based on random wave conditions which may include breaking and non-breaking waves. The guidance presented in the SPM (USACE 1984) are based on monochromatic (i.e. single sine wave) wave conditions. Furthermore, the SPM methodology is difficult to apply in situations where there are only a few breaking waves in the design wave spectrum. Accordingly, the Van der Meer methodology will be used as the basis for preliminary dike design. It has been incorporated into the USACE's Automated Coastal Engineering System (ACES) and has been recommended in lieu of the Hudson Equation in the USACE's EM-1614 Design of Coastal Revetments, Seawalls and Bulkheads (USACE 1985). Computations were made using Van der Meer's equations for each exposure direction.

Table 3-6 through 3-10 and the corresponding polar plots in Figures 3-6 through 3-10 show the results for stone sizes for a 3:1 side slope for Alignments 1, 2, 3, 4 and 5. For the 5-year storm at James Island, required stone sizes for dike sections exposed to the north are 2,000 pounds, 2,400 pounds, 2,700 pounds, 2,500 pounds and 2,500 pounds for Alignments 1, 2, 3, 4 and 5, respectively. For the 35-year storm, the required stone sizes for dike sections exposed to the north are 3,600 pounds, 4,200 pounds, 4900 pounds, 4,500 pounds and 4,500 pounds for Alignments 1, 2, 3, 4 and 5, respectively. For the 100-year storm, the required stone sizes for dike sections exposed to the north are 5,200 pounds, 6,000 pounds, 6,900 pounds, 6,500 pounds and 6,500 pounds for Alignments 1, 2, 3, 4 and 5, respectively. For dike sections exposed to winds from the east, the required stone size for the 5-year storm is 190 pounds for Alignments 1, 2, 3, 4 and 5, respectively. For the 35-year storm, the required stone sizes are 580 pounds and 710 pounds for Alignments 1 and 2 and Alignments 3, 4 and 5, respectively. For the 100-year storm, the required stone sizes are 850 pounds and 1,100 pounds for Alignments 1 and 2 and Alignments 3, 4 and 5, respectively.

The above armor stone requirements assume that the armor layer for the dike revetments will consist of two layers of placed rock. This is the normal design practice prescribed in the Shore Protection Manual and in many other coastal engineering references.

Table 3-6 Individual Armor Stone Weight (pounds) James Island – Alignment 1

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	2,000	260	190	70	1,400	1,200	1,400	1,700
10	2,500	410	310	120	1,700	1,300	1,500	1,800
15	2,700	520	390	160	1,900	1,500	1,600	1,900
20	3,000	640	490	210	2,100	1,700	1,700	2,100
25	3,200	740	520	240	2,300	1,800	1,800	2,200
30	3,500	820	550	280	2,400	1,900	1,800	2,300
35	3,600	940	580	310	2,600	2,100	1,900	2,400
40	3,800	1,000	610	340	2,700	2,200	2,000	2,400
50	4,200	1,200	670	410	3,000	2,400	2,100	2,600
100	5,200	1,400	850	540	3,800	3,000	2,400	3,000

Table 3-7 Individual Armor Stone Weight (pounds) James Island – Alignment 2

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	2,400	260	190	70	2,000	1,200	1,600	1,900
10	2,900	400	310	120	2,500	1,600	1,700	2,100
15	3,200	500	390	160	2,800	1,700	1,800	2,200
20	3,500	640	490	210	3,100	1,900	1,900	2,400
25	3,800	740	520	240	3,300	2,000	2,000	2,500
30	4,000	820	550	280	3,500	2,200	2,000	2,600
35	4,200	940	580	310	3,700	2,300	2,100	2,700
40	4,400	1,000	610	340	3,900	2,400	2,200	2,800
50	4,800	1,200	670	410	4,300	2,700	2,300	3,000
100	6,000	1,800	850	540	5,400	3,400	2,700	3,500

Table 3-8 Individual Armor Stone Weight (pounds) James Island – Alignment 3

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	2,700	260	190	70	2,000	1,000	1,300	1,900
10	3,300	410	310	120	2,500	1,200	1,400	2,100
15	3,700	520	390	160	2,800	1,300	1,500	2,200
20	4,000	640	500	210	3,100	1,500	1,600	2,400
25	4,300	740	560	240	3,300	1,600	1,600	2,500
30	4,600	820	640	280	3,500	1,700	1,700	2,600
35	4,900	940	710	310	3,700	1,800	1,800	2,700
40	5,100	1,000	790	340	3,900	1,900	1,800	2,800
50	5,500	1,200	880	410	4,300	2,100	1,900	3,000
100	6,900	1,800	1,100	670	5,400	2,700	2,300	3,500

Table 3-9 Individual Armor Stone Weight (pounds) James Island – Alignment 4

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	2,500	260	190	70	2,000	1,200	1,800	1,900
10	3,100	410	310	120	2,500	2,000	2,200	2,100
15	3,400	520	390	160	2,800	2,500	2,500	2,200
20	3,800	640	500	210	3,100	2,700	2,900	2,400
25	4,000	740	560	240	3,300	2,900	2,900	2,500
30	4,300	820	640	280	3,500	3,000	3,000	2,600
35	4,500	940	710	310	3,700	3,100	3,100	2,700
40	4,800	1,000	790	340	3,900	3,200	3,200	2,800
50	5,200	1,200	880	410	4,300	3,500	3,300	3,000
100	6,500	1,800	1,100	670	5,400	4,500	3,800	3,500

Table 3-10 Individual Armor Stone Weight (pounds) James Island – Alignment 5

Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	2,500	260	190	70	2,000	1,200	1,800	1,900
10	3,100	410	310	120	2,500	2,000	2,200	2,100
15	3,400	520	390	160	2,800	2,500	2,500	2,200
20	3,800	640	500	210	3,100	2,700	2,900	2,400
25	4,000	740	560	240	3,300	2,900	2,900	2,500
30	4,300	820	640	280	3,500	3,000	3,000	2,600
35	4,500	940	710	310	3,700	3,100	3,100	2,700
40	4,800	1,000	790	340	3,900	3,200	3,200	2,800
50	5,200	1,200	880	410	4,300	3,500	3,300	3,000
100	6,500	1,800	1,100	670	5,400	4,500	3,800	3,500

3.7 Scour Protection

Toe scour protection is the supplemental armoring of the bottom surface fronting a structure that prevents wave energy from scouring and undercutting it. Factors that affect the severity of toe scour include wave breaking, wave runup and rundown, wave reflection and grain size distribution of the beach or bottom materials. Toe stability is essential because failure of the toe will generally lead to failure throughout the entire structure. Toe scour is a complex process and specific design guidance has not been developed. Some general guidelines, however, have been suggested.

A berm toe apron has been selected for the project for several reasons: (1) the berm will provide greater protection to the structure from overtopping as a significant number of waves will break prior to reaching the side slope, (2) construction costs for a berm toe are generally lower than for a buried toe, (3) higher quantities of sediment can be suspended during excavation and construction of a buried toe, and (4) the construction methodology and environmental concerns associated with this project are better served by using a berm toe.

3.8 Underlayers and Filters

Revetments are normally constructed with an armor layer and one or more underlayers. Revetments often have two layers of armor and a thin underlayer overlying a geotextile built upon a core of sand or clay. Small particles beneath the geotextile should not be washed through the fabric and the underlayer stones should not be washed through the armor.

The SPM (1984) recommends that underlayer stone range of 1/10 to 1/15 of the armor weight. This results in a relatively large underlayer that has two advantages. First, a large underlayer permits surface interlocking with the armor. Second, a large underlayer gives a more permeable structure and therefore has an influence on the stability of the armor layer. For the dike design, the SPM criteria are recommended.

3.9 Dike Cross Sections

Figures 3-11 through 3-15 present the conceptual dike alignments for the James Island Restoration project. Seven different dike cross-sections have been developed for the alignment based on exposure direction. Figures 3-16 through 3-22 present the typical dike cross sections for each section along the alignment. The primary characteristics of the dike design are:

- Designs are based on 35-year return period storm conditions
- Designs incorporate a 3:1 side slope
- Dike heights are based on (1) allowable overtopping for an unarmored crest and (2) an allowance for settlement
- Stone sizes are computed using the Van der Meer method
- Above grade toe protection is used

- Core is constructed using sand
- A crushed stone roadway having a width of 20 ft is located on the structure crest.

Figure 3-16 shows Dike Section 1 for James Island Restoration Project. Dike Section 1 has a crest of +11.5 ft MLLW, and includes two layers of 5000 pound armor stone, two layers of 500 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 1 also has toe protection consisting of two layers of 2500 pound stone over a core of quarry run stone which covers a layer of geotextile on the existing bottom.

Figure 3-17 shows Dike Section 2 for James Island. Dike Section 2 has a crest of +11.0 ft MLLW, and includes two layers of 4000 pound armor stone, two layers of 400 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 2 also has toe protection consisting of two layers of 2000 pound stone over a core of quarry run stone which covers a layer of geotextile on the existing bottom.

Figure 3-18 shows Dike Section 3 for James Island. Dike Section 3 has a crest of +10.5 ft MLLW, and includes two layers of 3000 pound armor stone, two layers of 300 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 3 also has toe protection consisting of two layers of 1500 pound stone over a core of quarry run stone which covers a layer of geotextile on the existing bottom.

Figure 3-19 shows Dike Section 4 for James Island. Dike Section 4 has a crest of +9.5 ft MLLW, and includes two layers of 2500 pound armor stone, two layers of 250 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 4 also has toe protection consisting of two layers of 1300 pound stone over a core of quarry run stone which covers a layer of geotextile on the existing bottom.

Figure 3-20 shows Dike Section 5 for James Island. Dike Section 5 has a crest of +9.0 ft MLLW, and includes two layers of 2000 pound armor stone, two layers of 200 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 5 also has toe protection consisting of two layers of 1000 pound stone over a core of quarry run stone which covers a layer of geotextile on the existing bottom.

Figure 3-21 shows Dike Section 6 for James Island. Dike Section 6 has a crest of +7.0 ft MLLW, and includes two layers of 700 pound armor stone, two layers of 70 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 6 also has toe protection consisting of two layers of 350 pound stone over a core of quarry run stone which covers a layer of geotextile on the existing bottom.

Figure 3-22 shows Dike Section 7 for James Island, which differs significantly from Section 1 to 6. Dike Section 7 has a crest of +7.0 ft MLLW and 5:1 side slopes. Unlike sections 1 to 6, Section 7 is sand, with no armor stone, underlayer, quarry run stone, or geotextile.

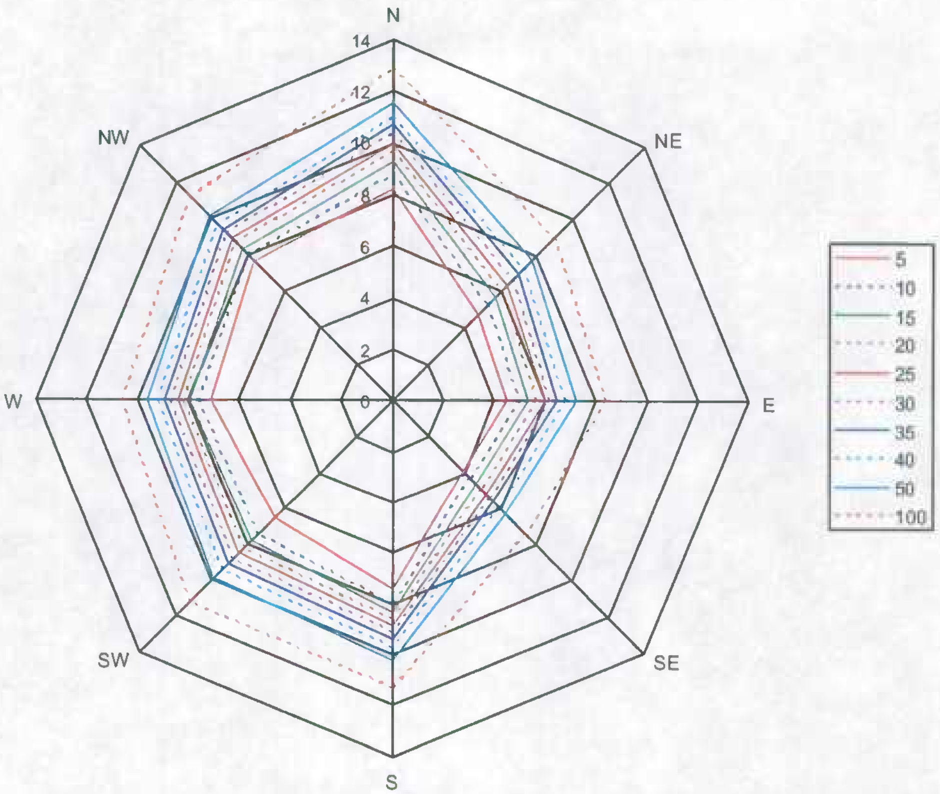


Figure 3-1. Required Crest Elevations (ft, MLLW) for James Island Alignment 1.

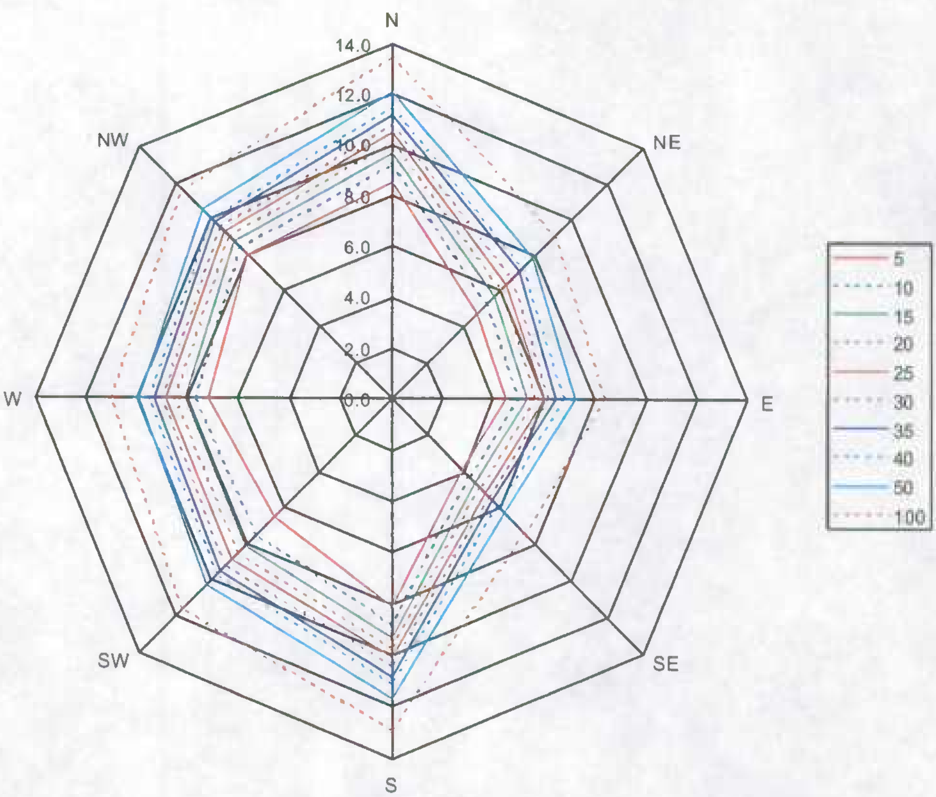


Figure 3-2. Required Crest Elevations (ft, MLLW) for James Island Alignment 2.

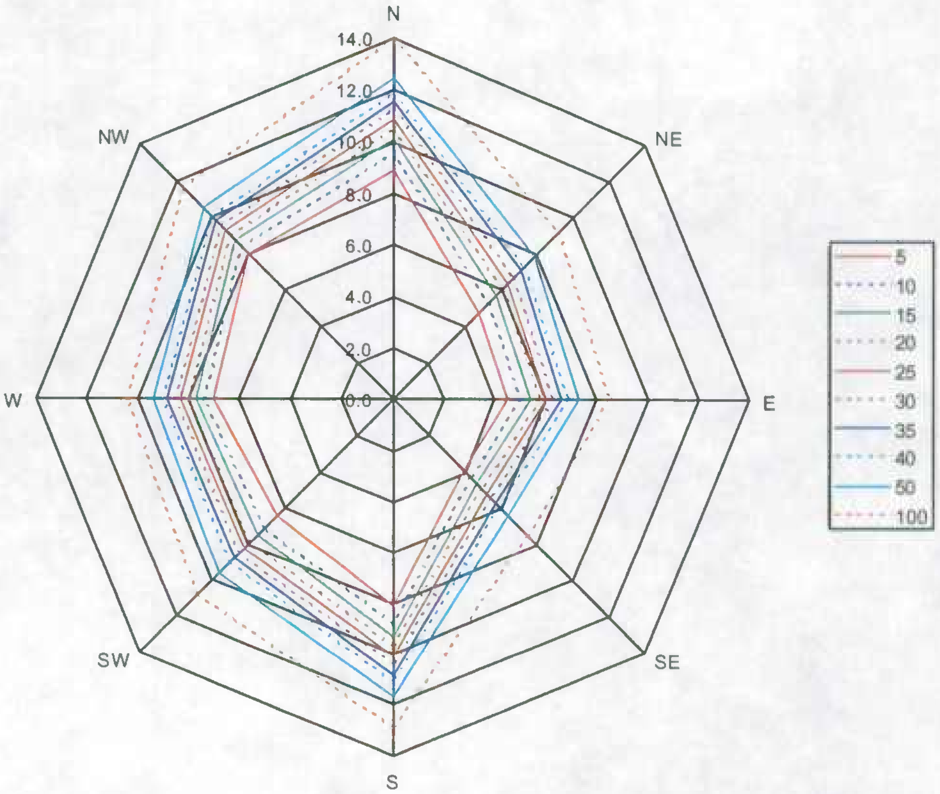


Figure 3-3. Required Crest Elevations (ft, MLLW) for James Island Alignment 3.

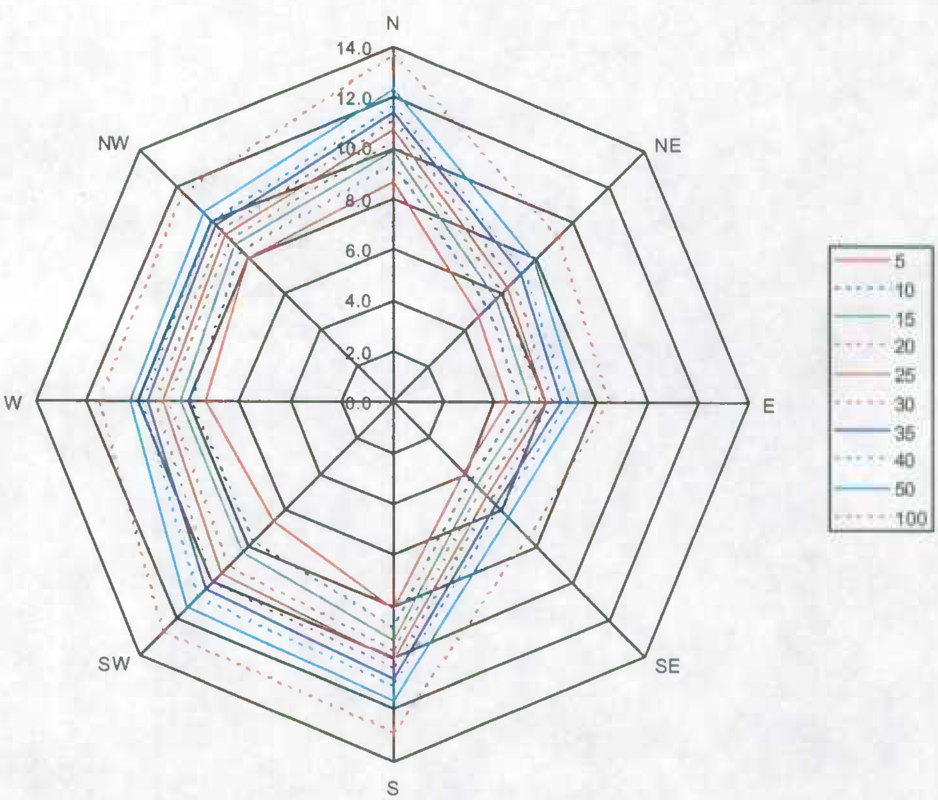


Figure 3-4. Required Crest Elevations (ft, MLLW) for James Island Alignment 4.

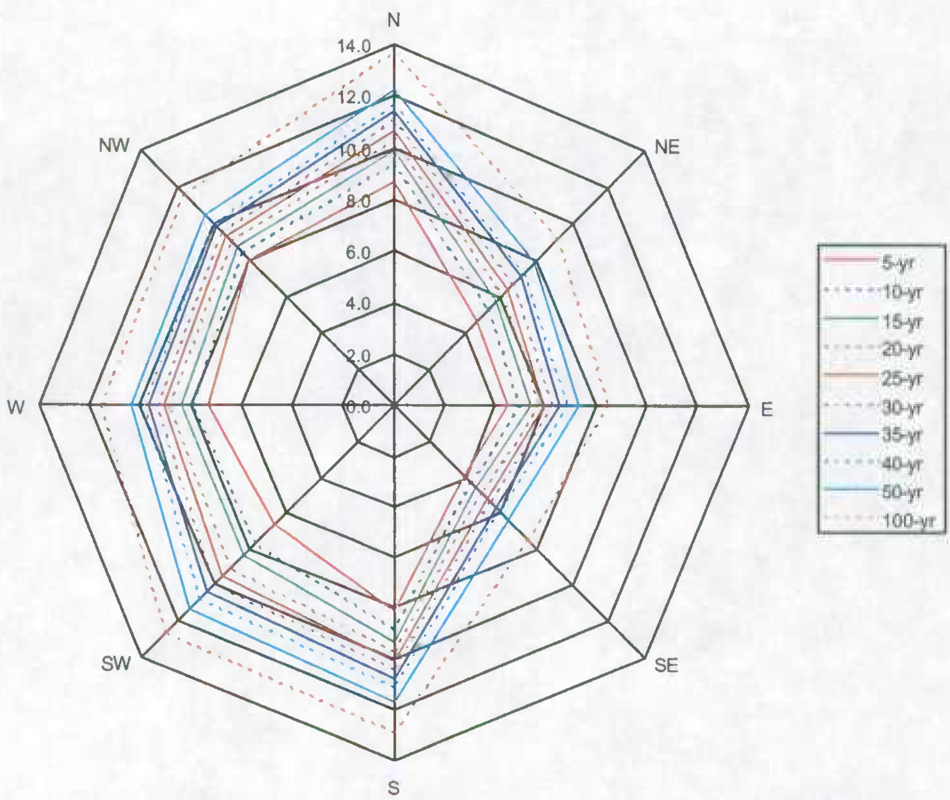


Figure 3-5. Required Crest Elevations (ft, MLLW) for James Island Alignment 5.

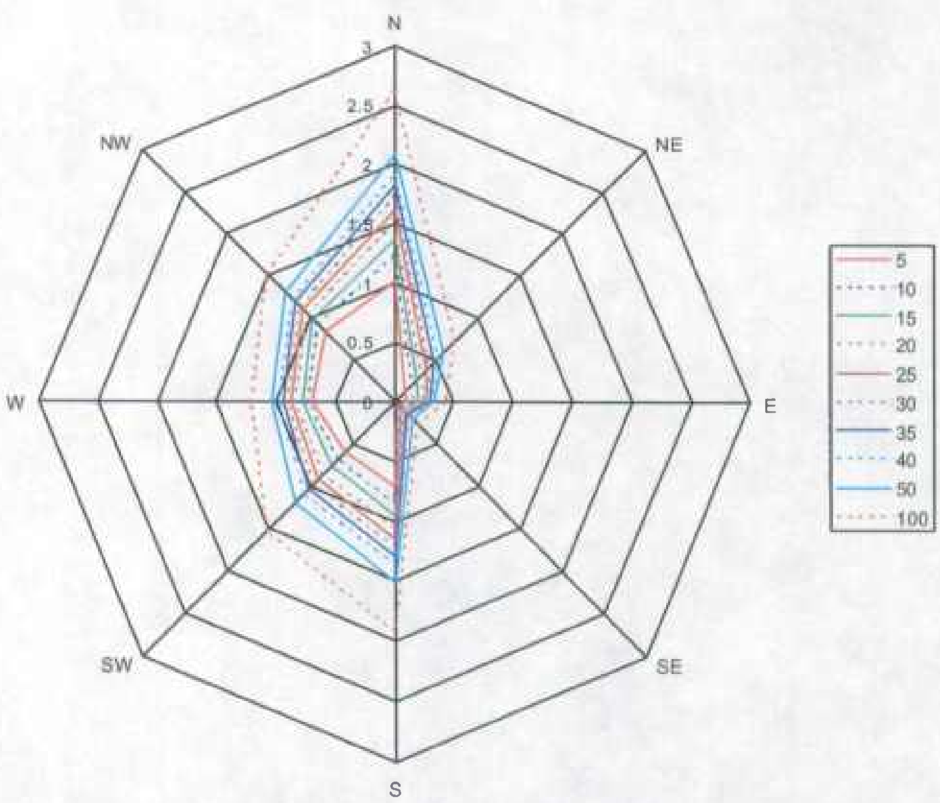


Figure 3-6. Required Armor Stone Sizes (ton) for James Island Alignment 1.

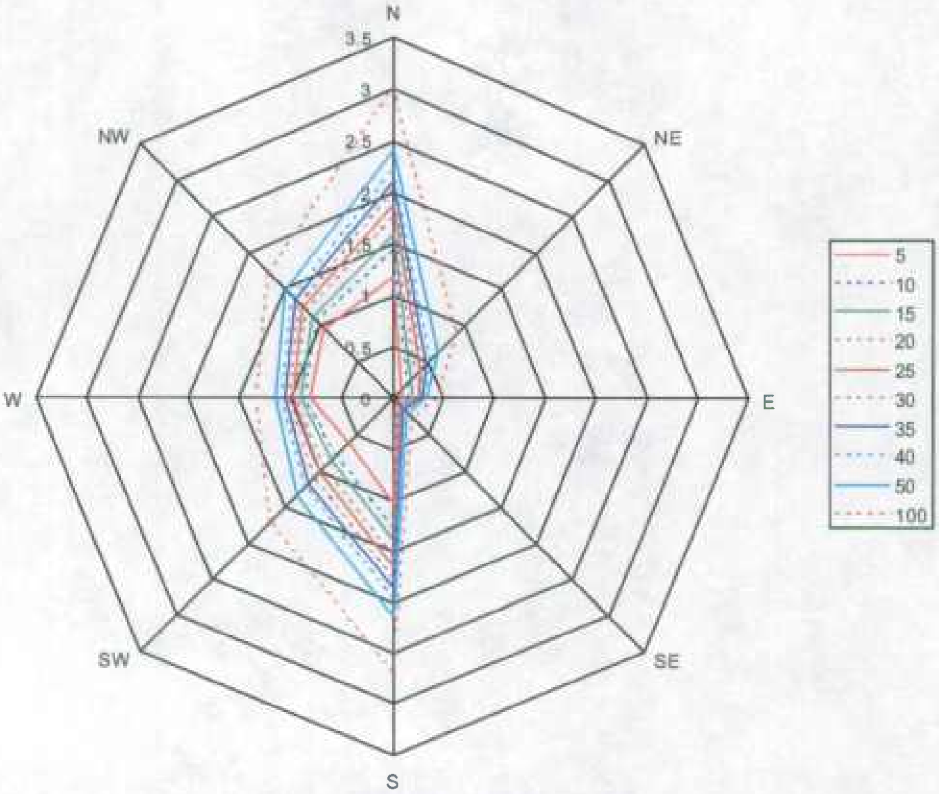


Figure 3-7. Required Armor Stone Sizes (ton) for James Island Alignment 2.

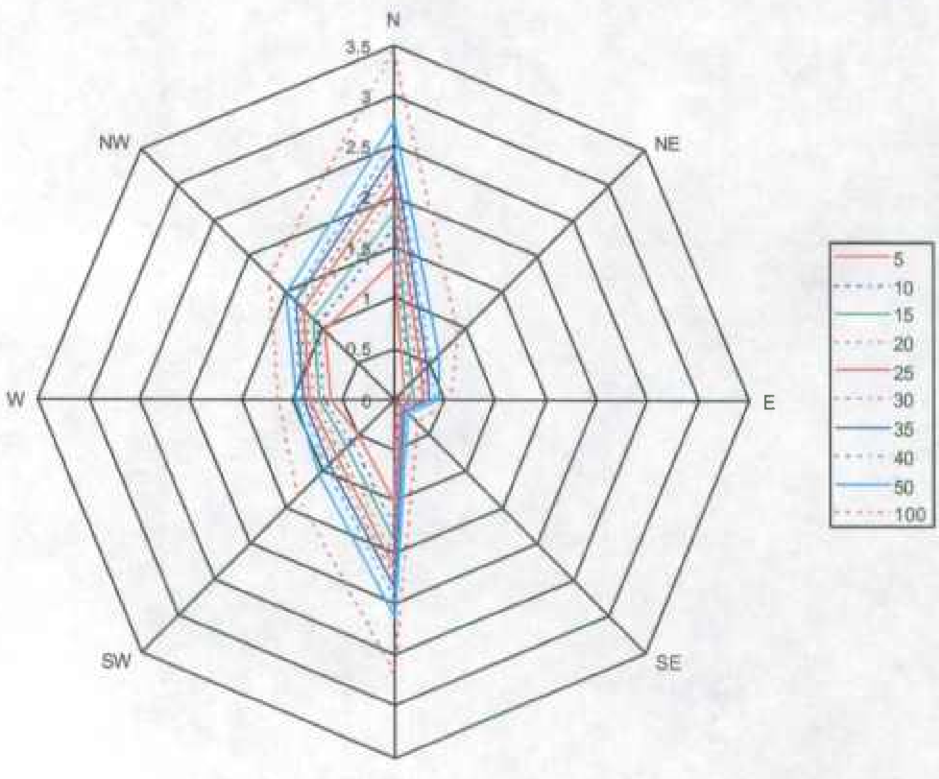


Figure 3-8. Required Armor Stone Sizes (ton) for James Island Alignment 3.

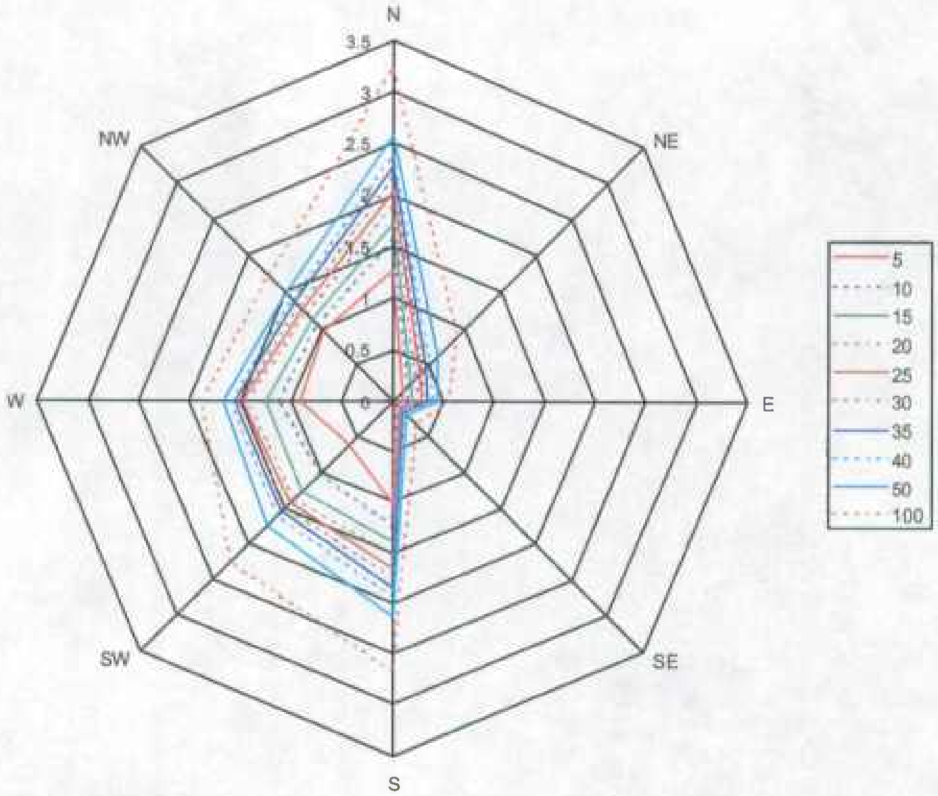


Figure 3-9. Required Armor Stone Sizes (ton) for James Island Alignment 4.

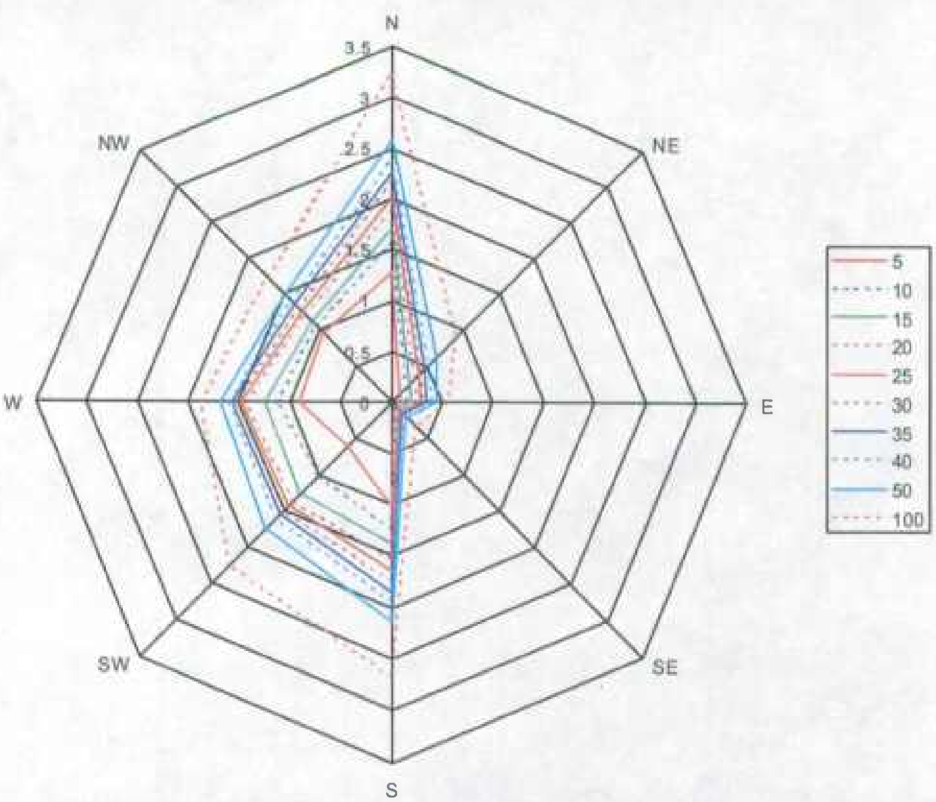
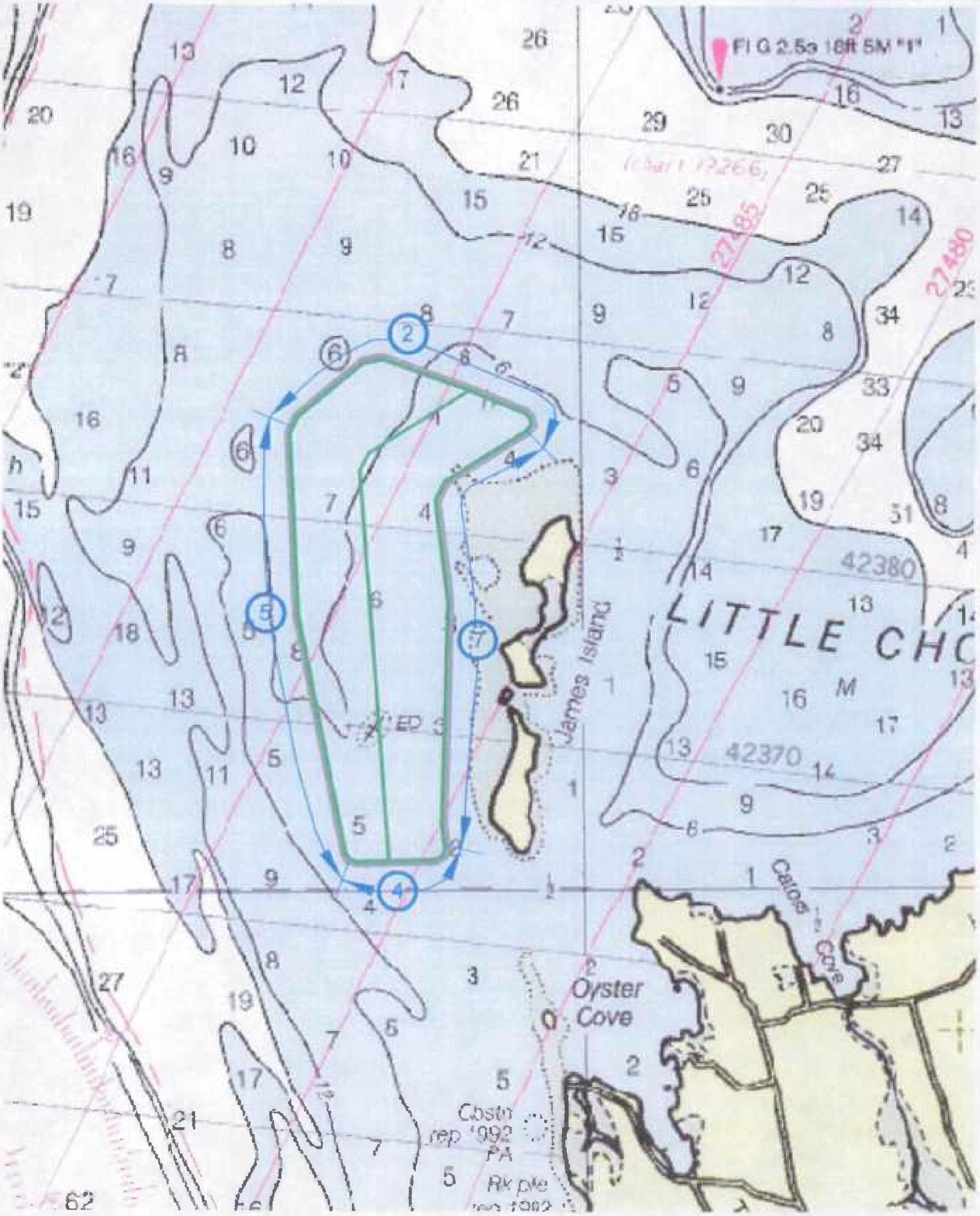


Figure 3-10. Required Armor Stone Sizes (ton) for James Island Alignment 5.



1 TYPICAL DIKE SECTION

0 3000

FEET

MOFFATT & NICHOL ENGINEERS BALTIMORE, MARYLAND	JAMES ISLAND RECONNAISSANCE STUDY PRELIMINARY COASTAL ENGINEERING ANALYSIS	FIGURE 3-11 DIKE SECTION LOCATION ALIGNMENT 1

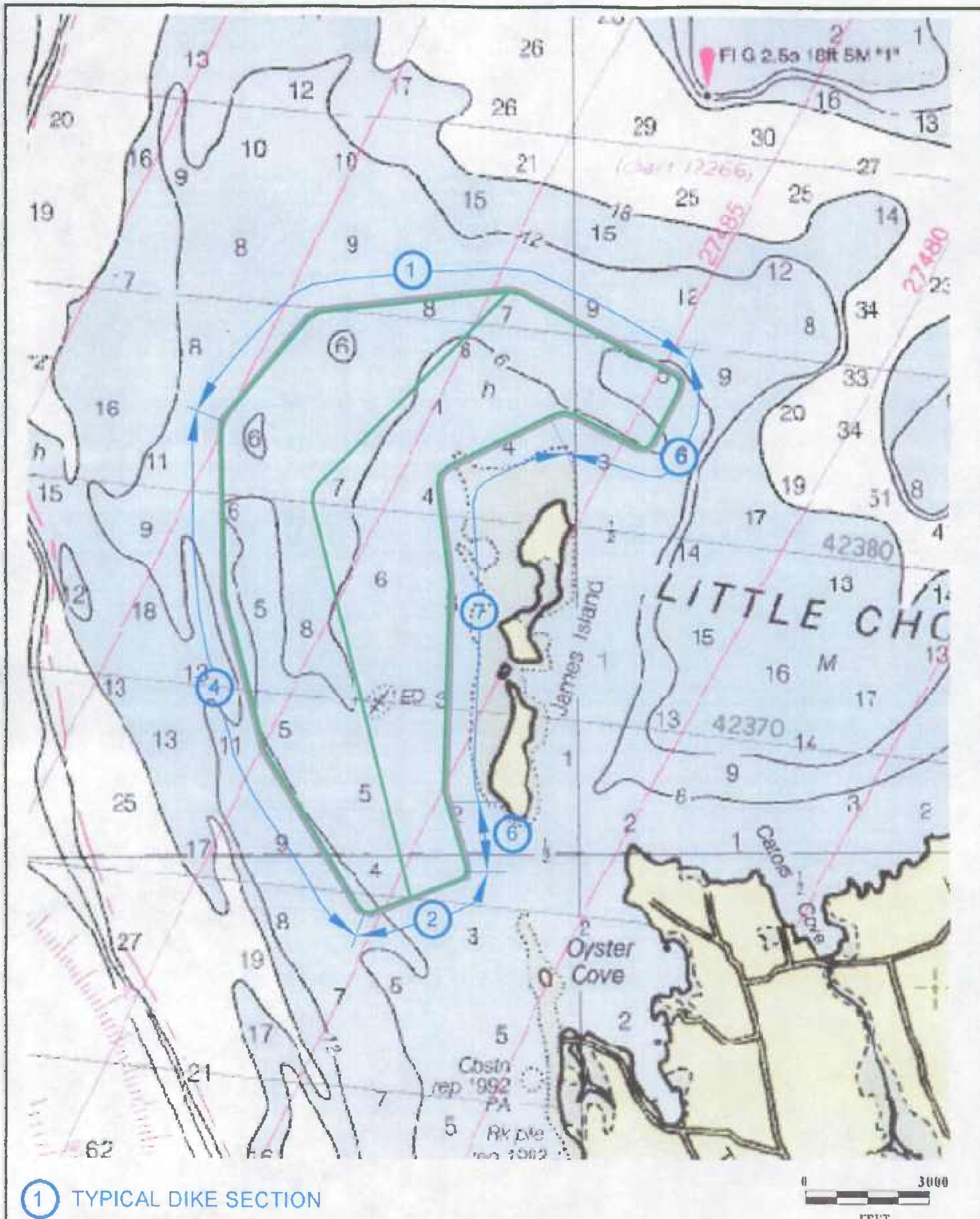


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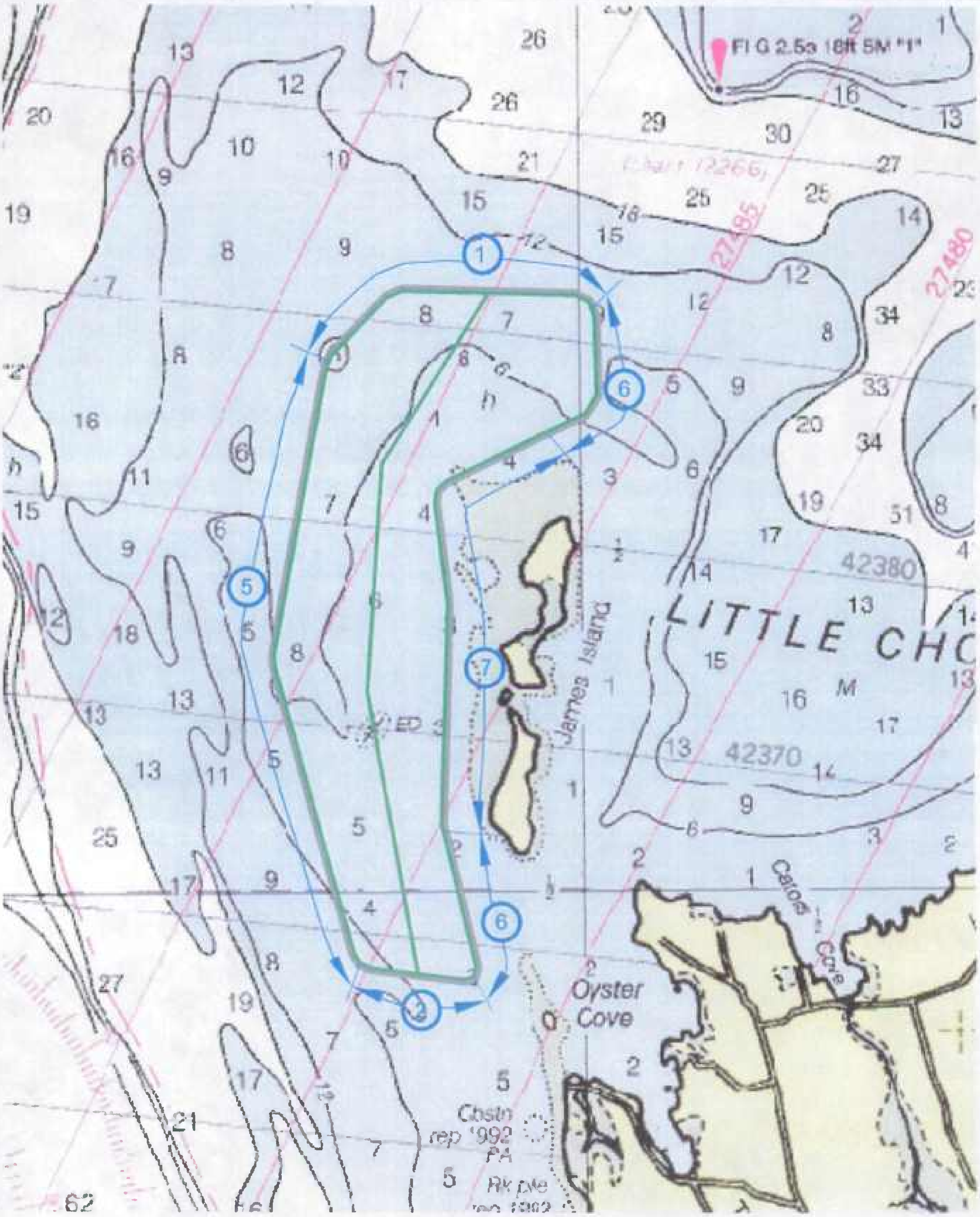
FIGURE 3-12
DIKE SECTION LOCATION
ALIGNMENT 2



1 TYPICAL DIKE SECTION

0 3000
FEET

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FIGURE 3-13
DIKE SECTION LOCATION
ALIGNMENT 3

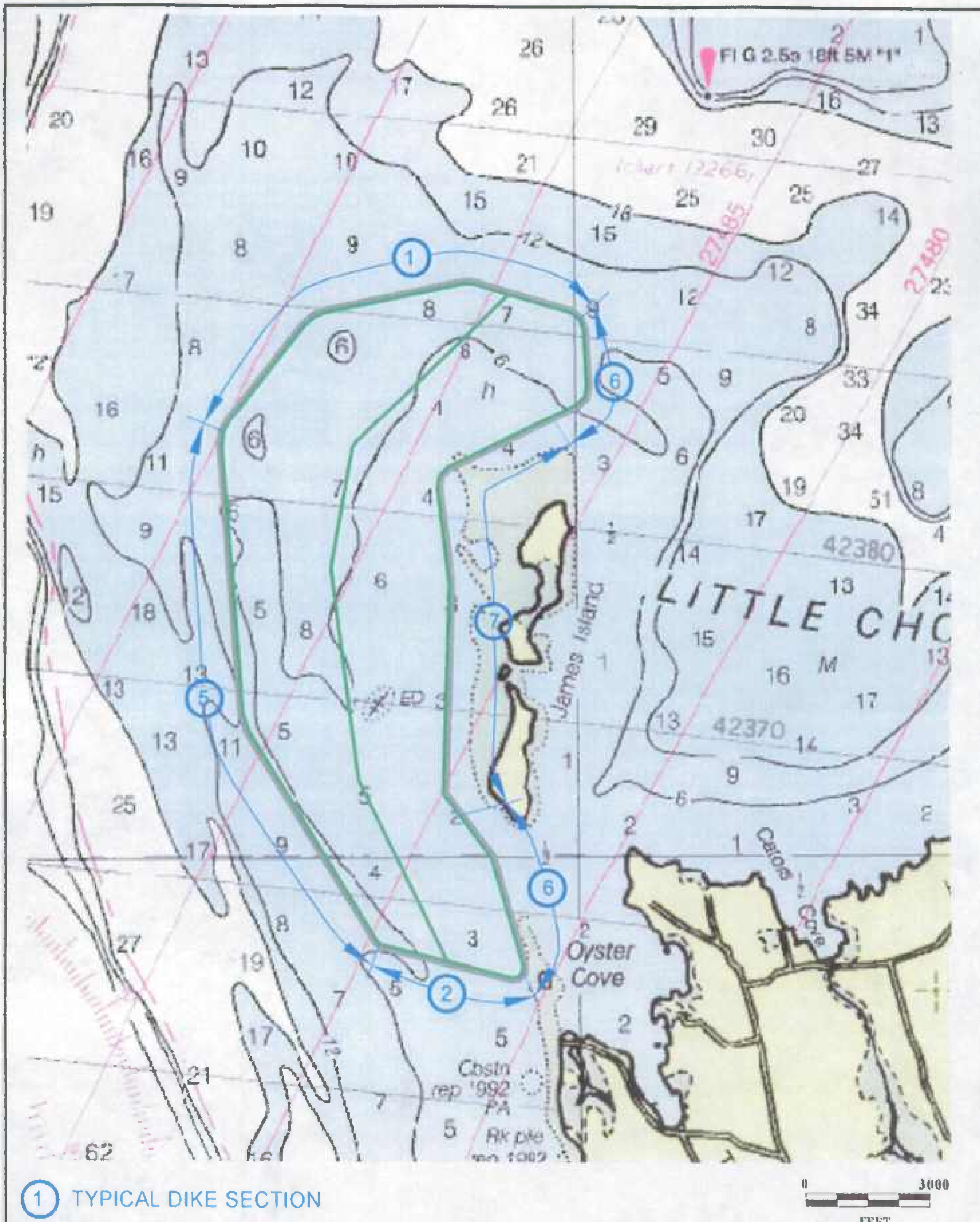

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FIGURE 3-14
DIKE SECTION LOCATION
ALIGNMENT 4

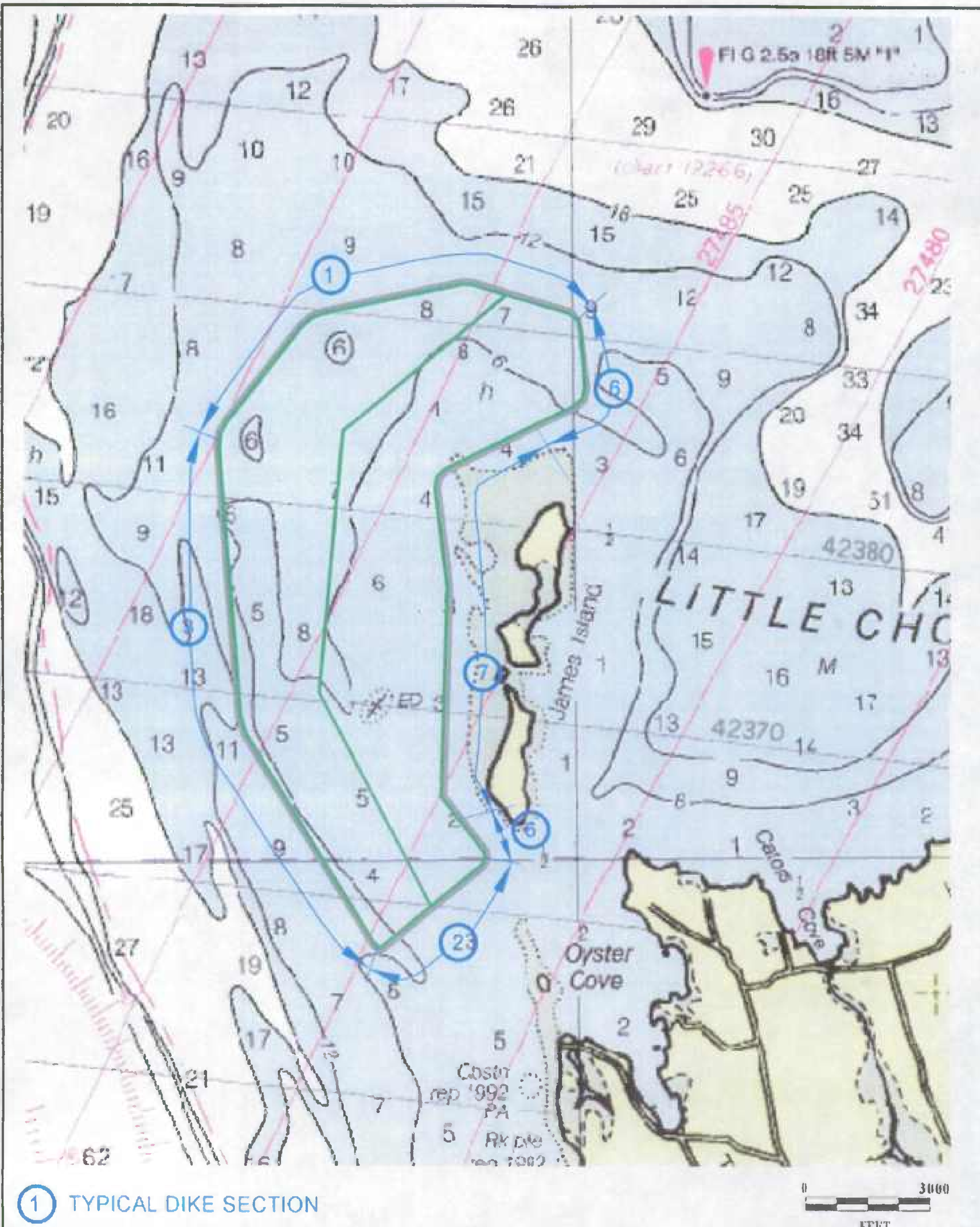

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FIGURE 3-15
DIKE SECTION LOCATION
ALIGNMENT 5

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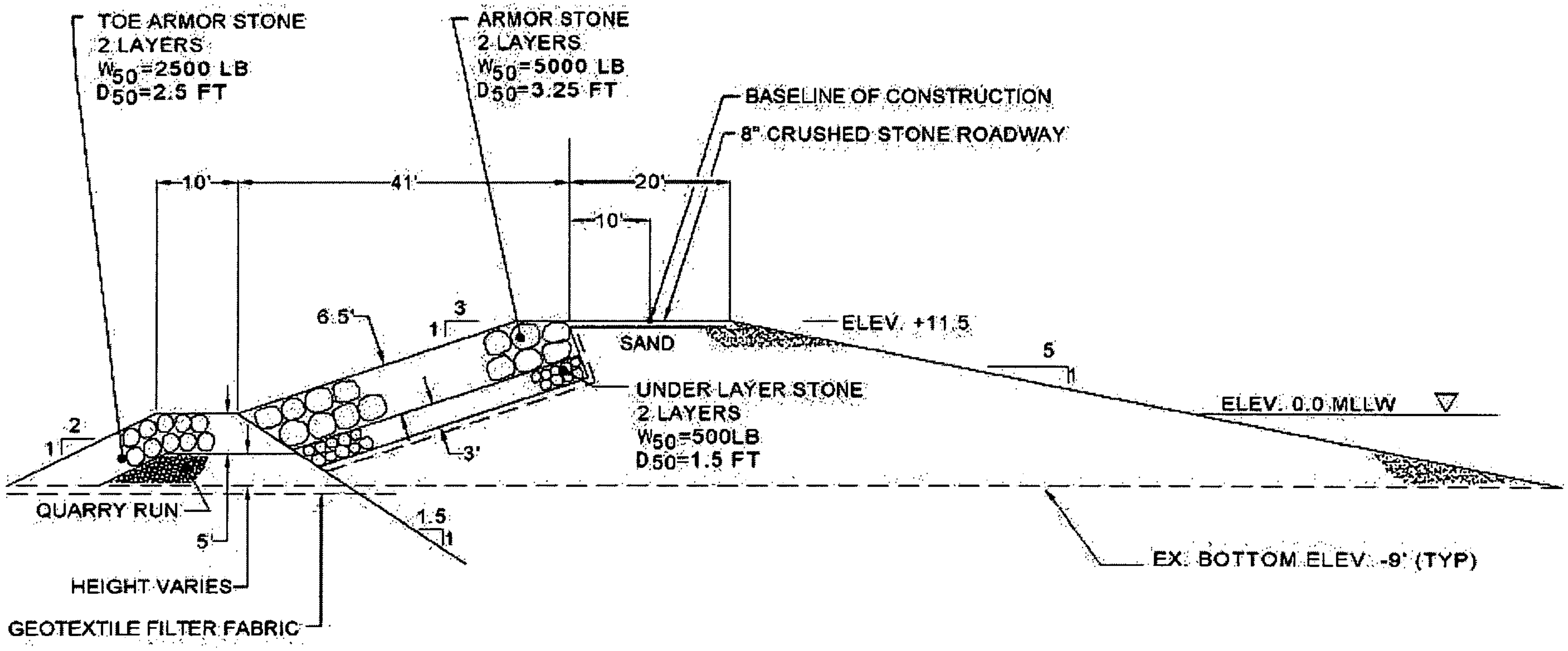
FIGURE 3-16
TYPICAL DIKE SECTION NO. 1



TYPICAL DIKE SECTION NO. 1

1" = 20'

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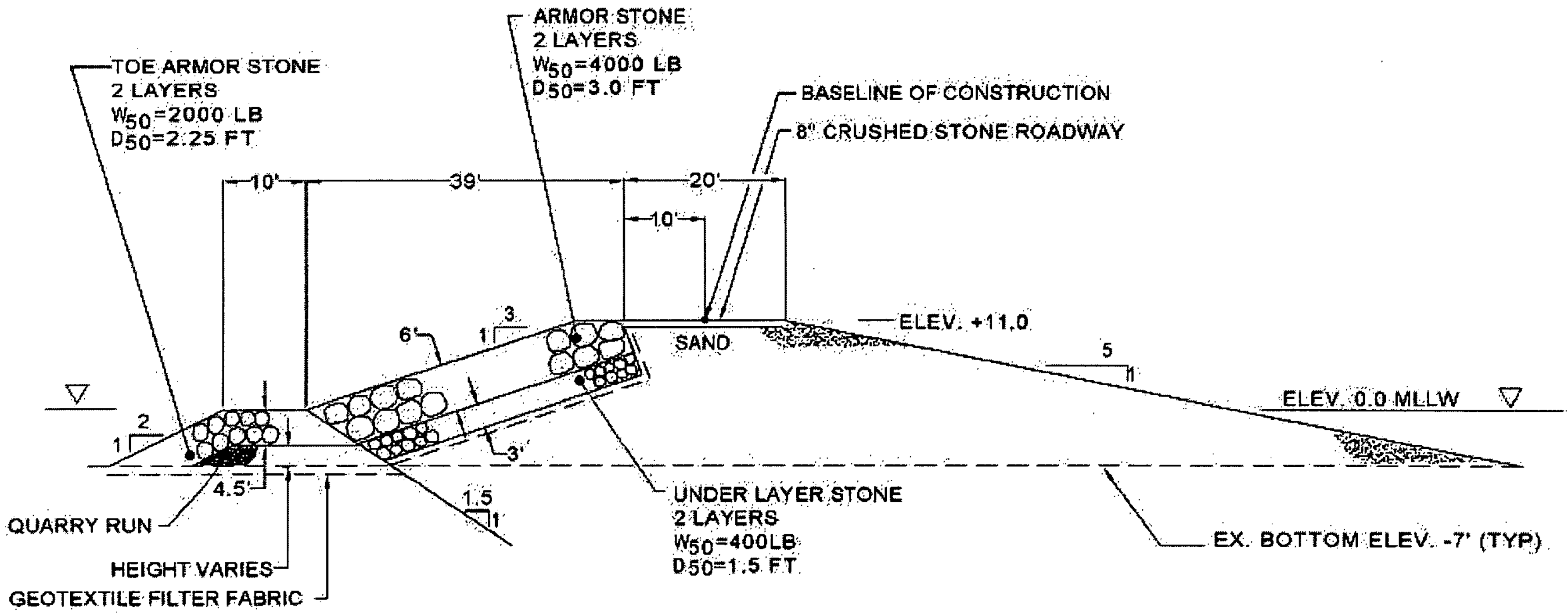

TYPICAL DIKE SECTION NO. 2

1" = 20'

FIGURE 3-17
TYPICAL DIKE SECTION NO. 2

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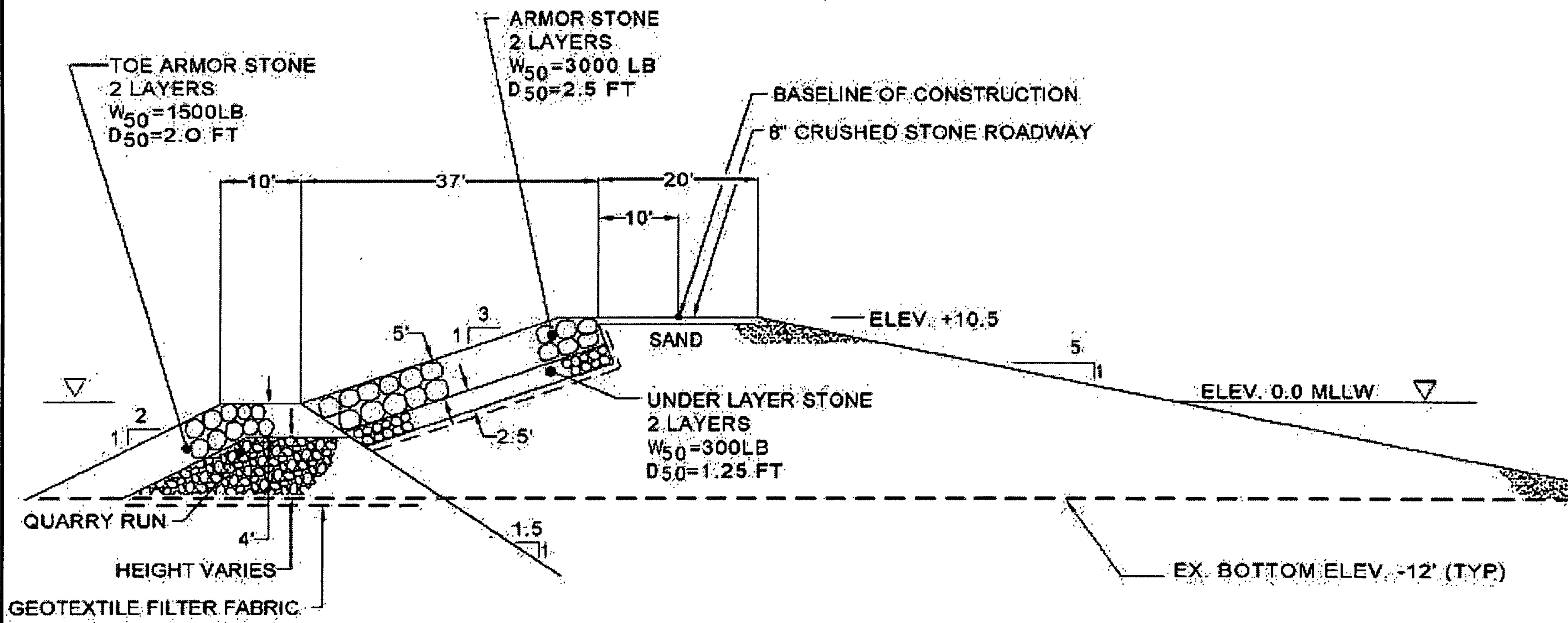

TYPICAL DIKE SECTION NO. 3

1" = 20'

FIGURE 3-18
TYPICAL DIKE SECTION NO. 3

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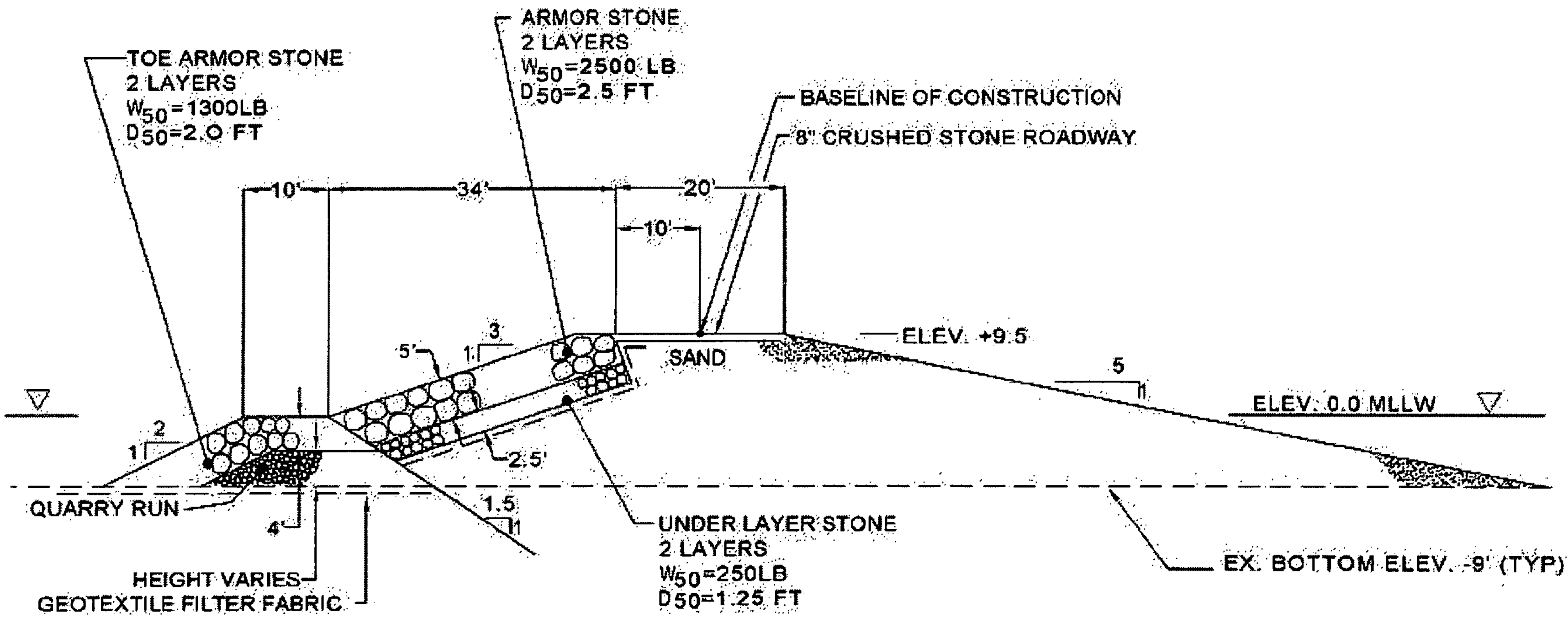
FIGURE 3-19
TYPICAL DIKE SECTION NO. 4



TYPICAL DIKE SECTION NO. 4

1" = 20'

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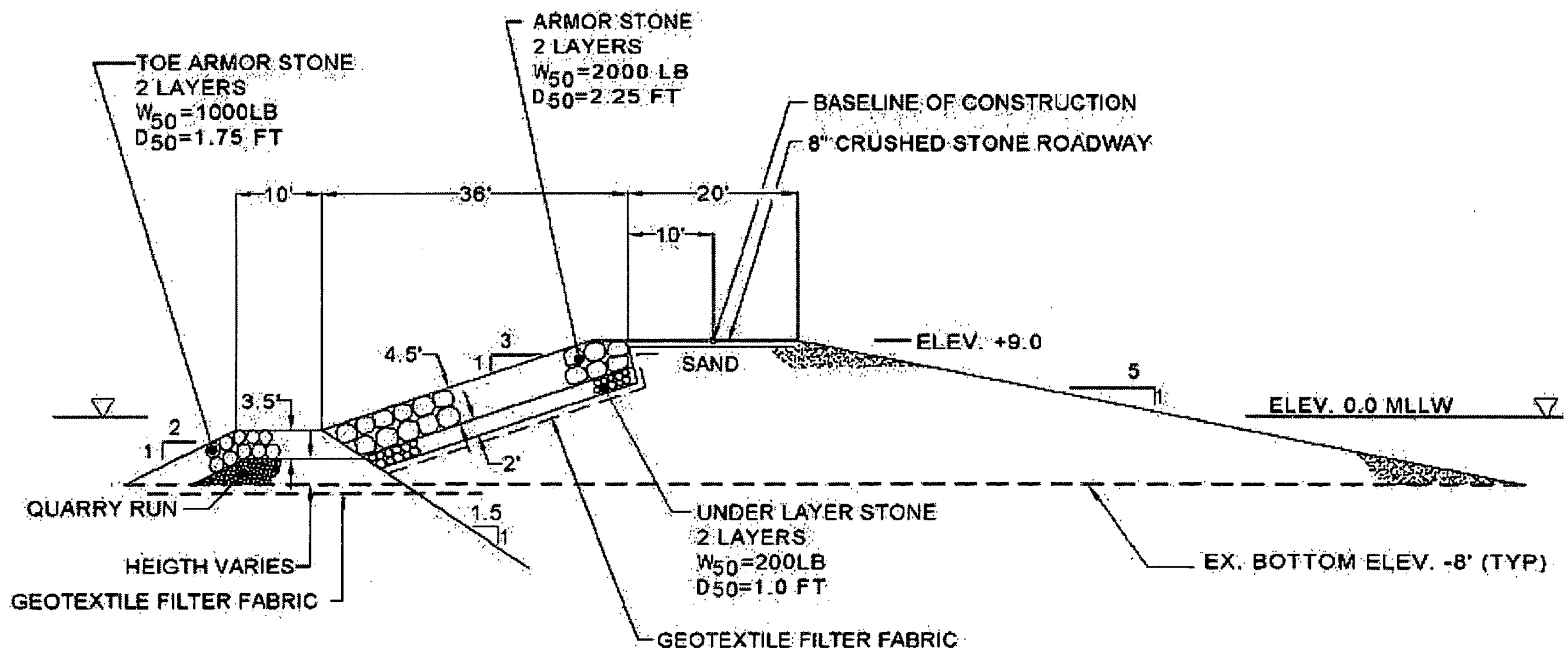
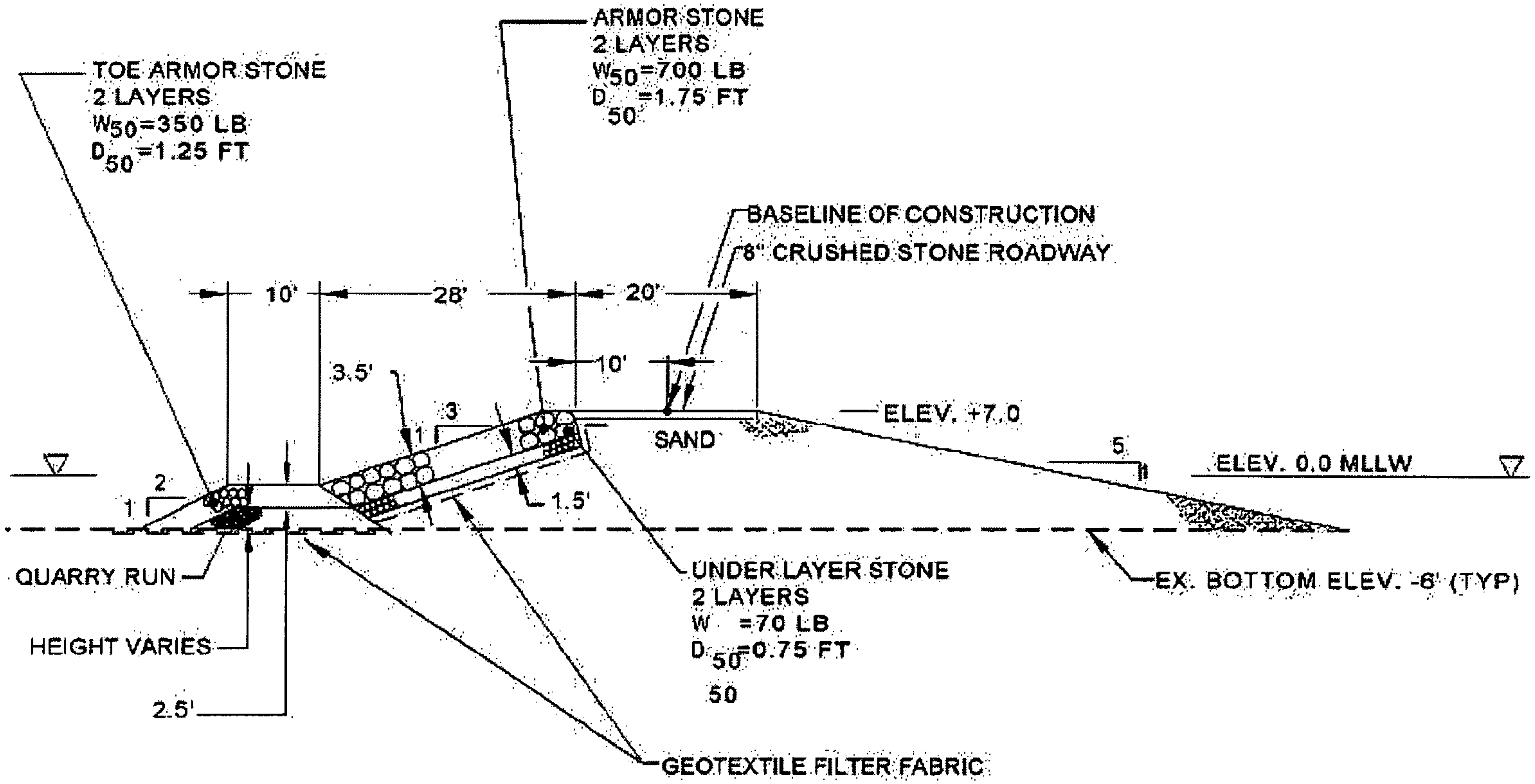
FIGURE 3-20
TYPICAL DIKE SECTION NO. 5



TYPICAL DIKE SECTION NO. 5

1" = 20'



TYPICAL DIKE SECTION NO. 6

1" = 20'

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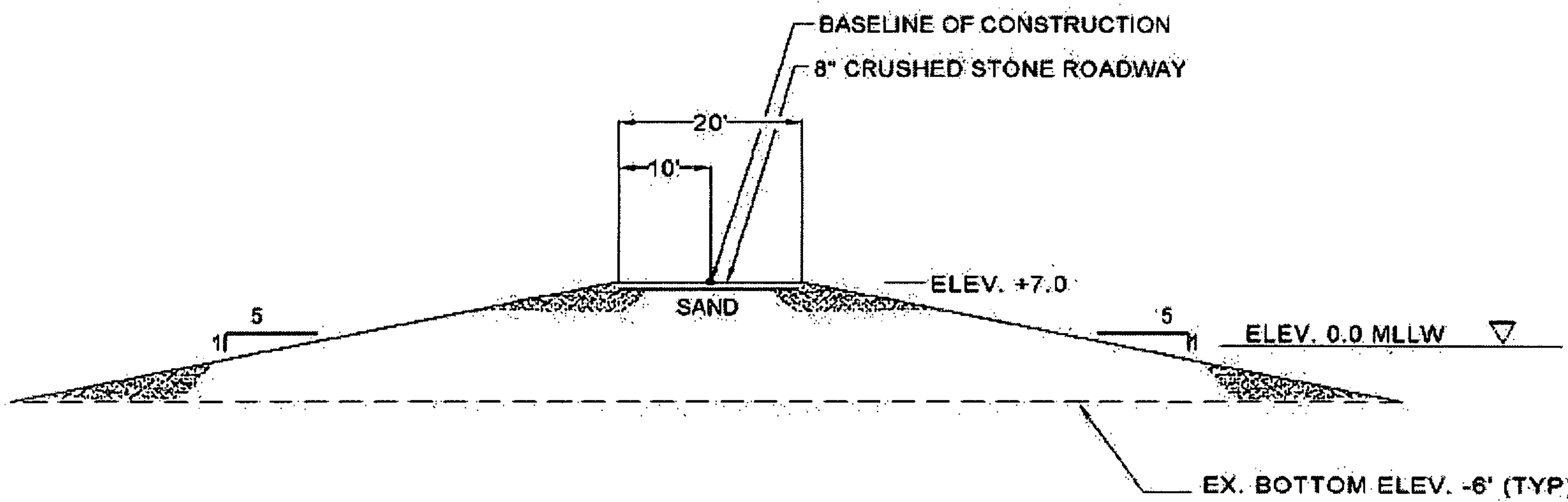
JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 3-21
TYPICAL DIKE SECTION NO. 6



TYPICAL DIKE SECTION NO. 7

1" = 20'

MOFFATT & NICHOL ENGINEERS
BALTIMORE, MARYLAND

JAMES ISLAND RECONNAISSANCE STUDY
PRELIMINARY COASTAL ENGINEERING ANALYSIS

FIGURE 3-22
TYPICAL DIKE SECTION NO. 7

4. SUMMARY

4.1 Site Conditions

This Coastal Engineering Investigation report provides information on the James Island site being considered for a beneficial use of dredged material project. This report addresses evaluation of existing available data pertaining to environmental site conditions and coastal engineering aspects for the design of the diked enclosure.

Water depths in the area where the dikes would be located range from –2 to –12 ft MLLW, with an average depth along the exterior dikes ranging from –3 to –12 ft MLLW.

Design winds for the site are developed from data collected at Baltimore-Washington International (BWI) Airport. Design wind speeds are calculated for return periods ranging from 5 to 100 years for eight wind directions including the direction with the longest fetch (north and south).

Normal water levels at the site are dictated by astronomical tides. Mean tide level is 0.9 ft above MLLW. Design water levels for the project area are dominated by storm surge which for a 100-year return period can be as high as 5.6 ft above MLLW.

The highest waves for the site approach from both the north and south directions. For Alignment 1, predicted peak spectral wave period and significant offshore, significant nearshore and maximum nearshore wave heights for the north direction for the 5-year storm are 4.9 seconds, 5.4 ft, 4.6 ft, and 7.6 ft, respectively. The predicted peak spectral wave period and significant offshore, significant nearshore and maximum nearshore wave heights for the north direction for the 35-year storm are 5.8 seconds, 8.2 ft, 5.1 ft and 8.6 ft, respectively. The predicted peak spectral wave period, significant offshore, significant nearshore and maximum nearshore wave heights for the 100-year storm acting on Alignment 1 from the north are 6.4 seconds, 10.1 ft, 5.6 ft and 9.6 ft, respectively.

The highest waves for Alignment 2 approach from the north and south. For Alignment 2, predicted peak spectral wave period and significant offshore, significant nearshore and maximum nearshore wave heights for the north direction for the 5-year storm are 4.9 seconds, 5.4 ft, 5.0 ft, and 8.1 ft, respectively. The predicted peak spectral wave period and significant offshore, significant nearshore and maximum nearshore wave heights for the north direction for the 35-year storm are 5.8 seconds, 8.2 ft, 5.5 ft and 9.3 ft, respectively. The predicted peak spectral wave period, significant offshore, significant nearshore and maximum nearshore wave heights for the 100-year storm acting on Alignment 2 from the north are 6.4 seconds, 10.1ft, 6.0 ft and 10.2 ft, respectively.

The highest waves for Alignment 3 approach from the north and south. For Alignment 3, predicted peak spectral wave period and significant offshore, significant nearshore and maximum nearshore wave heights for the north direction for the 5-year storm are 4.9 seconds, 5.4 ft, 5.3 ft, and 8.7 ft, respectively. The predicted peak spectral wave period and significant offshore, significant nearshore and maximum nearshore wave heights for the north direction for the 35-year storm are 5.8 seconds, 8.2 ft, 5.9 ft and 9.9 ft, respectively. The predicted peak spectral wave period, significant offshore, significant nearshore and maximum nearshore wave heights for the 100-year storm acting on Alignment 3 from the north are 6.4 seconds, 10.1ft, 6.4 ft and 10.8 ft, respectively.

The highest offshore waves for Alignment 4 approach from the north and south. However, due to deeper water depths, the largest nearshore waves approach from the southwest. For Alignment 4, predicted peak spectral wave period and significant offshore wave heights for the north direction for the 5-year storm are 4.9 seconds and 5.4 ft, respectively. The predicted peak spectral wave period and significant offshore wave heights for the north direction for the 35-year storm are 5.8 seconds and 8.2 ft, respectively. The predicted peak spectral wave period and significant offshore wave heights for the 100-year storm acting on Alignment 4 from the north are 6.4 seconds and 10.1ft, respectively. The 5-year storm significant nearshore and maximum nearshore waves from the southwest are 3.9 ft and 7.0 ft, respectively. The 35-year storm significant nearshore and maximum nearshore waves from the southwest are 6.5 ft and 10.0, respectively. The 100-year storm nearshore significant and nearshore maximum waves from the southwest are 7.1 ft and 11.0 ft, respectively.

The highest offshore waves for Alignment 5 approach from the north and south. Similarly to Alignment 4, deeper water depths allow the largest nearshore waves to approach from the southwest. For Alignment 5, predicted peak spectral wave period and significant offshore wave heights for the north direction for the 5-year storm are 4.9 seconds and 5.4 ft, respectively. The predicted peak spectral wave period and significant offshore wave heights for the north direction for the 35-year storm are 5.8 seconds and 8.2 ft, respectively. The predicted peak spectral wave period and significant offshore wave heights for the 100-year storm acting on Alignment 5 from the north are 6.4 seconds and 10.1ft, respectively. The 5-year storm significant nearshore and maximum nearshore waves from the southwest are 3.9 ft and 7.0 ft, respectively. The 35-year storm significant nearshore and maximum nearshore waves from the southwest are 6.5 ft and 10.0, respectively. The 100-year storm nearshore significant and nearshore maximum waves from the southwest are 7.1 ft and 11.0 ft, respectively.

Currents in the project area are relatively weak, with a maximum velocity of 1 ft/sec and are not considered critical to design the shore protection. However, current patterns could be affected by island restoration. The effects of the dike construction will be investigated in the Hydrodynamics and Sedimentation Modeling Report for this study.

Results of the preliminary study by E2CR indicate that the underlying soil is silty sand. There are, however, areas with soft silty clays at the mud line which will need to be undercut and backfilled with sand.

4.2 Coastal Protection Dike Design

Seven preliminary cross-sections were developed for the containment dikes. The dike designs are based upon a 35-year return period. Dike heights are based on allowable overtopping for an unarmored crest and an allowance for settlement. Stone sizes are computed using the Van der Meer method. The designs incorporate 3:1 side slope, above grade toe protection, a core constructed of sand, and a crushed stone roadway on the structure crest.

Figure 3-16 shows Dike Section 1 for James Island Restoration Project. Dike Section 1 has a crest of +11.5 ft MLLW, and includes two layers of 5000 pound armor stone, two layers of 500 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 1 also has toe protection consisting of two layers or 2500 pound stone over quarry run stone and geotextile.

Figure 3-17 shows Dike Section 2 for James Island Restoration Project. Dike Section 2 has a crest of +11.0 ft MLLW, and includes two layers of 4000 pound armor stone, two layers of 400 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 2 also has toe protection consisting of two layers or 2000 pound stone over quarry run stone and geotextile.

Figure 3-18 shows Dike Section 3 for James Island Restoration Project. Dike Section 3 has a crest of +10.5 ft MLLW, and includes two layers of 3000 pound armor stone, two layers of 300 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 3 also has toe protection consisting of two layers or 1500 pound stone over quarry run stone and geotextile.

Figure 3-19 shows Dike Section 4 for James Island Restoration Project. Dike Section 4 has a crest of +9.5 ft MLLW, and includes two layers of 2500 pound armor stone, two layers of 250 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 4 also has toe protection consisting of two layers or 1300 pound stone over quarry run stone and geotextile.

Figure 3-20 shows Dike Section 5 for James Island Restoration Project. Dike Section 5 has a crest of +9.0 ft MLLW, and includes two layers of 2000 pound armor stone, two layers of 200 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 5 also has toe protection consisting of two layers or 1000 pound stone over quarry run stone and geotextile.

Figure 3-21 shows Dike Section 6 for James Island Restoration Project. Dike Section 6 has a crest of +7.0 ft MLLW, and includes two layers of 700 pound armor stone, two layers of 70 pound underlayer stone overlaying a geotextile that separates the stone revetment from the dike core. Dike Section 6 also has toe protection consisting of two layers or 350 pound stone over quarry run stone and geotextile.

Figure 3-22 shows Dike Section 7 for James Island, which differs significantly from Sections 1 to 6. Dike Section 7 is constructed entirely of sand and has a crest of +7.0 ft MLLW and 5:1 side slopes.

4.3 Conclusions

This Coastal Engineering Investigation indicates that construction of dikes to create a beneficial use of dredged material/environmental restoration project is feasible from a coastal engineering standpoint. Design of the dikes is similar to those used for the Poplar Island Environmental Restoration Project. The majority of the proposed island will be exposed to waves sufficient to require armor. The east side of the proposed island is sheltered from waves, and thus will have a sand dike. Five Alignments were evaluated, resulting in seven dike sections with elevations ranging from +7.0 ft MLLW to +11.0 ft MLLW and armor ranging from no armor to 5000 pound armor stone. The five alignments each would require four to five different dike cross-sections.

4.4 Recommendations

This report presents a reconnaissance level investigation and design for the James Island Restoration Project. Should this study move forward it is suggested that a feasibility study be conducted using the recent bathymetric surveys made in the vicinity of James Island.

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APPENDIX C

Appendix C:

Hydrodynamics and Sedimentation Modeling

(Moffatt and Nichol Engineers)

JAMES ISLAND RECONNAISSANCE STUDY

HYDRODYNAMICS AND SEDIMENTATION MODELING

FINAL REPORT NOVEMBER 15, 2002

Maryland Port Administration
MPA Contract Number: 500912
MPA Pin Number: 600105-P

Maryland Environmental Services
MES Contract Number: 02-07-49

Prepared by

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EXECUTIVE SUMMARY

The purpose of this Hydrodynamics and Sedimentation Modeling Reconnaissance Study is to evaluate the projected impacts due to construction of a Beneficial Use Habitat Restoration Site at James Island. Moffatt & Nichol Engineers' (MNE) Upper Chesapeake Bay – Finite Element Model (UCB-FEM) (MNE, 2000) was used to predict existing conditions and with- and without-project hydrodynamics and sedimentation. This report summarizes the calibration and implementation of the UCB-FEM two-dimensional numerical model of the Chesapeake Bay and evaluation of hydrodynamic and sedimentation output including time-varying flow velocity, water surface elevations, and patterns of erosion and accretion.

A summary of site conditions that are relevant to the project is provided below:

- **Bathymetry and Topography.** Water depths in the area where the dikes would be located range from –2 to –12 ft Mean Lower Low Water (MLLW), with an average depth along the exterior dikes ranging from –3 to –12 MLLW. Water depths in the deeper main stem portions of the Bay west of James Island are as great as –93 ft MLLW.

- **Freshwater Inflow.** The drainage area of the Chesapeake Bay is approximately 64,000 square miles and includes portions of Maryland, Virginia, West Virginia, Pennsylvania, New York and the District of Columbia. Freshwater enters the Chesapeake Bay via approximately 150 major rivers and streams at approximately 80,000 cubic ft per second (Schubel and Pritchard, 1987).

- **Tides.** Water levels in the Chesapeake Bay are dominated by a semidiurnal lunar tide. Tides enter the Bay via the Chesapeake Bay entrance and the Chesapeake and Delaware (C&D) Canal. The mean range of tides throughout the entire Chesapeake Bay is generally 1 to 3 ft (NOS, 1988). In the project vicinity, the mean tide level is 0.9 ft above MLLW; the mean tidal range is 1.3 ft and the spring tidal range is 1.8 ft (NOS 1997).

- **Currents.** In the project vicinity, approximately 2.5 miles west of James Island, peak flood currents are about 1.0 ft/sec, and peak ebb currents are about 0.8 ft/sec (NOS, 1996). Currents are not considered important for shore protection design at this project site.

- **Wind and Wave Conditions.** Design winds for the site were developed on the basis of data collected at Baltimore-Washington International (BWI) airport. These winds, which can exceed 90 miles per hour during a 100-year storm event, were used to develop design wave conditions. James Island is exposed to wind-generated waves approaching from all directions.

- **Site Soil Characteristics.** Results of the separate geotechnical preliminary study indicate that the underlying soil consists of silty sand, suitable for supporting the dike. Areas with soft silty clays at the mud line, however, would need to be undercut and backfilled with sand.

The numerical modeling system used in this study consists of the US Army Corps of Engineers finite element hydrodynamics (RMA-2) and sedimentation (SED-2D) models – collectively known as TABS-2 (Thomas, McAnally and Ademac, 1985). The numerical modeling system uses a bathymetric mesh of water depths, represented by nodes located in the horizontal plane that are interconnected to create elements.

Correlation of the hydrodynamic model calibration results to NOAA predicted data for tidal elevations and current velocities is generally better than 90%. Predicted percent error is typically less than 10% for tidal elevations and less than 15% for current velocity.

The non-cohesive sediment model was run using 0.1mm (.004 inch) sediment under no-wind conditions. Analysis of results shows negligible sand transport due to tidal currents. Modeled non-cohesive sediment transport for existing conditions is negligible for 4- and 13-mph winds for all directions. Sixteen-mph winds, when taken cumulatively with lower wind speeds, account for nearly 90% of the yearly wind occurrences and cause significant sediment transport for winds from the NNW and SSE directions with less sediment transport for winds from other directions.

The cohesive sediment model was run for a 6-month simulation period at which point the model achieved a dynamic equilibrium (average values and rates remain steady over time). The cohesive sediment model was then run for each of 16 wind directions for wind speeds of 4- and

13-mph.

Hydrodynamics and sedimentation numerical modeling for the James Island Reconnaissance Study show minimal impacts on local tidal elevations, which are essentially unchanged. Current velocities are impacted following island construction, with maximum increase or decrease in current velocity of about 0.4 ft/sec. Construction at James Island also would have beneficial effects on sedimentation rates and patterns, with less erosion of the James Island shoreline and the shallow areas surrounding the remnant James Islands. Some protection would also be afforded to the shoreline of Taylors Island from wind and waves coming from the N, NNW, and NW directions. This reduction in erosion would likely cause reduced suspended sediment and improved water quality.

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ACRONYMS AND SYMBOLS

CDF	–	Confined Disposal Facility
DEM	–	Digital Elevation Map
E	–	Erosion rate constant
H_s	–	Nearshore Significant Wave Height
MCY	–	Million Cubic Yards
Mi	–	Statute Mile (5,280 Feet)
MLLW	–	Mean Lower Low Water
MPH	–	Miles Per Hour
NGVD	–	National Geodetic Vertical Datum
Nmi	–	Nautical Mile (6,076 Feet)
NCDC	–	National Climatic Data Center
NOS	–	National Ocean Service
NOAA	–	National Oceanic and Atmospheric Administration
ρ	–	Bulk Density
RMA-2	–	Hydrodynamic Model (by United States Army Corps of Engineers)
RMS	–	Root Mean Square
SED-2D	–	Sediment Transport Model (by United States Army Corps of Engineers)
SPM	–	Shore Protection Manual
T_p	–	Peak Spectral Wave Period
τ_{cd}	–	Critical Shear Stresses of Deposition
τ_{ce}	–	Critical Shear Stresses of Erosion
UCB-FEM	–	Upper Chesapeake Bay Finite Element Model (by Moffatt & Nichol Engineers)
USACE	–	United States Army Corps of Engineers
USGS	–	United States Geological Survey
w_s	–	Settling Velocity
WES	–	Waterways Experiment Station (of the United States Army Corps of Engineers)

1. INTRODUCTION

1.1 STUDY PURPOSE AND OBJECTIVES

The purpose of this Hydrodynamics and Sedimentation Numerical Modeling Reconnaissance Study report is to analyze the projected impacts due to construction of a Beneficial Use and Habitat Restoration Site at James Island as regards hydrodynamics and sedimentation in the site vicinity. Moffatt & Nichol Engineers' (MNE) Upper Chesapeake Bay – Finite Element Model (UCB-FEM) (MNE, 2000) was modified to include James Island and used to predict with- and without-project hydrodynamics and sedimentation.

Study objectives include the following:

- Comparison of with- and without-project tidal elevations
- Comparison of with- and without-project current velocities
- Comparison of with- and without-project relative sedimentation rates and patterns for non-cohesive and cohesive sediments

The proposed five alignments are compared to existing conditions, both graphically and numerically, to determine both specific and relative impacts.

1.2 PROJECT SCOPE

James Island is being studied as a potential site for beneficial use of dredged material. Benefits of this project include:

- Protection of the remnant James Island and Taylors Island shorelines from additional erosion
- Protection of the shallow water surrounding James Island to provide improved water quality and subsequently promote the re-establishment of subaquatic vegetation

To accomplish these objectives, the project consists of the construction of armored dikes that would serve to contain clean sediments dredged from the Baltimore Harbor approach channels located within the Chesapeake Bay.

1.3 STUDY DESCRIPTION

This report summarizes the calibration and implementation of a two-dimensional numerical model of the Chesapeake Bay to evaluate the impacts of construction at the James Island Restoration Site on tidal elevations, current velocity conditions, and sedimentation patterns.

The existing UCB-FEM model was modified to provide additional detail near James Island and was re-calibrated with published data, including astronomical tidal information, tidal current velocity information, and streamflow discharge for existing conditions. The calibrated model was used to compare hydrodynamic and sedimentation conditions within the model domain for the proposed construction alignment.

The UCB-FEM model was developed based on the following U.S. Army Corps of Engineers (USACE) numerical models:

- RMA-2: A depth-averaged finite element model for the simulation of velocities and water elevations for river systems, estuaries and other shallow water bodies. The model can be applied in either a one- or two-dimensional mode.

- SED-2D: A two-dimensional flow model for sediment transport related to unsteady flows. The model is based on the solution of the depth-averaged convection-diffusion equations of sediment with bed source terms. SED-2D is capable of modeling cohesive and non-cohesive sediment transport.

Assumptions critical to these numerical modeling efforts include:

- Calibration and application of the UCB-FEM hydrodynamic model was performed based on available data for normal tide and freshwater discharge conditions for existing conditions.

- Hydrodynamic conditions are analyzed to ascertain potential changes arising from construction of the James Island project.

- Sedimentation modeling was performed to estimate the change in bay sedimentation and scouring patterns and relative rates if the James Island project was constructed.

- All results are subject to limitations of existing data, modeling capabilities and existing information regarding environmental resources and historical records. Hence, results depicted herein may be subject to modification in any additional future study stages as additional information is made available.

UCB-FEM hydrodynamic output includes time-varying flow velocity and water surface elevation fields. The UCB-FEM model also evaluates and predicts areas where erosion and accretion are likely to occur.

2. PROJECT SITE PHYSICAL CONDITIONS

2.1 GENERAL

James Island is located in the Chesapeake Bay at the mouth of the Little Choptank River. It is located in Dorchester County at approximately 38° 31' N latitude and 76° 20' W longitude (Maryland State Plane Coordinates N 310,000 E 1,503,000) as shown in Figure 2-1. Figure 2-2 is an aerial photograph of James Island taken in August 2002. Figure 2-3 shows the proposed five alignments for James Island.

Site conditions germane to project design include bathymetry and topography, water levels, currents, wind and wave conditions, and site soil characteristics. A discussion of each of these factors is presented in the following paragraphs.

2.2 BATHYMETRY AND TOPOGRAPHY

The Chesapeake Bay is the largest estuary in the United States, extending over 200 miles from its seaward end at Cape Charles and Cape Henry in Virginia to the mouth of the Susquehanna River at Havre de Grace, Maryland. The Chesapeake Bay (including tributaries) has a surface area of approximately 4,500 square miles. Water depths in the Bay, including all of its tidal tributaries, average approximately 21 feet (ft) with a few deep troughs reaching a maximum depth of 174 ft (Schubel and Pritchard, 1987).

Chesapeake Bay bathymetric data was obtained from the National Ocean Service (NOS) Digital Elevation Models (NOS, 2000) and Charts 12230, 12263, 12264, 12266, 12268, 12270, 12272, 12273, 12274, and 12278. Vertical and horizontal data in this report are referenced to mean lower low water (MLLW) based on the 1960 to 1978 tidal epoch, and the Maryland State Plane, North American Datum 1983, respectively.

The bathymetry surrounding James Island is shown in Figure 2-3. Water depths within the project vicinity vary from -2 ft to -12 ft MLLW; maximum water depths in which the new containment dikes would be constructed is -12 ft MLLW. Water depths approximately one mile west of James Island are as great as -93 ft MLLW.

2.3 FRESHWATER INFLOW

The drainage area of the Chesapeake Bay is approximately 64,000 square miles and includes portions of Maryland, Virginia, West Virginia, Pennsylvania, New York and the District of Columbia. Freshwater enters the Chesapeake Bay via approximately one-hundred and fifty major rivers and streams at approximately 80,000 cubic ft per second (Schubel and Pritchard, 1987). The primary rivers within the Chesapeake Bay drainage basin are the Susquehanna, Chester, Severn, Choptank, Patuxent, Nanticoke, Potomac, Rappahannock, York, and James Rivers. The Susquehanna River provides approximately 48.2% of the total freshwater inflow into the bay. Additional rivers on the western shore of the Bay, which contribute significant flows are the Potomac, James, Rappahannock, York, and Patuxent, contributing 13.6%, 12.5%, 3.1% 3.0% and 1.2%, respectively. Two significant sources of freshwater flow on the eastern shore of Maryland and Virginia are the Choptank (1.2%) and Nanticoke (1.1%) Rivers (Schubel and Pritchard, 1987).

2.4 TIDES

Water levels in the Chesapeake Bay are dominated by a semidiurnal lunar tide. Tides enter the Bay via the Chesapeake Bay Entrance and the Chesapeake and Delaware (C&D) Canal. The Bay is sufficiently long to contain one complete wavelength of the semidiurnal tide (NOS, 1988). The combination of tides and freshwater inflow creates a spring tide approximately 30-40% larger than mean tide and a neap tide approximately 30-40% smaller than the mean tide (Schubel and Pritchard, 1987).

The mean range of tides throughout the entire Chesapeake Bay is generally 1 to 3 ft (NOS, 1988). Tides are amplified in some tributaries as the tide progresses from the mouth of the tributary to the limit of the tide.

Average and spring tidal ranges, as published by NOS for the Bay north of the Potomac River (NOS Chart Nos. 12263, 12266, 12268, 12270, 12272), are listed in Table 2-1.

Table 2-1: Chesapeake Bay Tidal Ranges

Location	Mean Tidal Range (ft)	Spring Tidal Range (ft)
Main Chesapeake Bay		
Cove Point	1.3	2.0
Bloody Point Bar Light	1.3	1.6
Pooles Island	1.2	1.8
Sevenfoot Knoll Light	0.9	1.3
Western Chesapeake Bay		
Fairhaven, Herring Bay	0.9	1.3
Thomas Point Shoal Light	0.9	1.4
Annapolis	0.9	1.4
Sandy Point	0.8	1.2
Baltimore (Ft. McHenry)	1.2	1.7
Pond Point	1.4	2.1
Choptank River		
Cambridge	1.7	2.4
Chesapeake Beach	1.0	1.5
Eastern Bay		
St. Michaels, Miles River	1.2	1.8
Kent Island Narrows	1.2	1.8
Chester River		
Love Point	1.2	1.7
Queenstown	1.3	2.0
Cliffs Wharf	1.5	2.2
Chestertown	1.8	2.7
Sassafras River		
Betterton	1.6	2.4
C & D Canal		
Chesapeake City	2.8	2.9
Susquehanna River		
Havre de Grace	1.8	2.6

Average tides range from 0.8 ft in various locations on the western shore to 2.8 ft in the C & D Canal. Spring tides (tides occurring at or near the time of new or full moon which rise highest and fall lowest from the mean sea level) range from 1.3 ft at Fairhaven on Herring Bay to 2.9 ft in the C & D Canal. Near James Island, mean tide range is approximately 1.3 ft (NOS, 1996).

Additionally, tides in the Chesapeake Bay are influenced by Coriolis forces (momentum forces due to the rotation of the Earth). Browne and Fisher (NOS, 1988) found a significant west to east tide range differential due to Coriolis forces throughout the bay with peak differences of 1.0 foot in the region between Smith Point (1 foot range, western shore) and Tangier Sound (2 foot range, eastern shore).

2.5 CURRENTS

Currents in the Chesapeake Bay are tidally driven and range in values up to a maximum velocity of over 3 ft/sec near the Bay entrance (NOS, 1988). Peak current velocities in the Bay north of Kent Island approach 1.5 ft/sec and average 1.2 ft/sec. Phasing of current velocity is influenced by bottom friction. Browne and Fisher (NOS, 1988) determined that during a given tidal cycle the peak current velocity occurs first in the center of the bay over the deepest channels, whereas peak velocity occurs later closer to shore in shallower water.

In the project vicinity, approximately 2.5 miles west of James Island, peak tidal current velocities are approximately 1.0 ft/sec for flood currents and 0.8 ft/sec for ebb currents (NOS, 1996).

2.6 WIND AND WAVE CONDITIONS

The frictional force of air on water as wind blows generates waves. Higher winds, deeper water, and longer distances over which the wind travels result in larger waves. Wind and wave conditions representative of the James Island vicinity are discussed in the following paragraphs.

2.6.1 Wind Conditions

Average annual wind speeds at James Island are represented by the wind rose shown in Figure 2-4. The wind rose represents percent occurrence of wind speeds and directions at Baltimore-Washington International (BWI) Airport as reported by the National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NOS, 1982 and NCDC, 1994). Table 2-2 shows the data used to generate the wind rose.

In Table 2-2, 0 to 3 mph winds are considered "calm" with indeterminate direction, resulting in these winds being grouped together for all directions. On average, nearly 90% of the yearly wind occurrences are less than 16 mph and only 1-2% of wind occurrences are greater than 25 mph.

Table 2-2: Wind Speed (% Occurrence) By Direction for BWI Airport, 1951-1982

Direction	0-3 MPH	4-13 MPH	13-16 MPH	16-19 MPH	19-25 MPH	25-32 MPH	>32 MPH
N		3.6	0.6	0.3	0.1	0	0
NNE		2.1	0.4	0.2	0.1	0	0
NE		3.3	0.5	0.2	0.1	0	0
ENE		3.3	0.6	0.3	0.1	0	0
E		4.3	0.5	0.2	0	0	0
ESE		2.3	0.2	0.1	0	0	0
SE		3.1	0.4	0.2	0.1	0	0
SSE		3.2	0.5	0.2	0.1	0	0
S		5.2	0.6	0.3	0.1	0	0
SSW		3.5	0.7	0.3	0.2	0	0
SW		4.7	0.8	0.4	0.2	0	0
WSW		4.7	0.6	0.3	0.1	0	0
W		9.4	1.4	1.0	0.7	0.2	0
WNW		5.9	1.8	1.5	1.3	0.4	0
NW		4.4	1.6	1.2	0.7	0.2	0
NNW		3.0	0.8	0.5	0.2	0	0
ALL	10.2						

Annual extreme wind speed data from the NOAA, NCDC for BWI Airport for the period 1951 through 1982 (NOS, 1982 and NCDC, 1994) are presented in Table 2-3 as fastest mile winds. Fastest mile winds are defined as the highest recorded wind speeds that last long enough to travel one mile during a 24-hour recording period. For example, a fastest mile wind speed of 60 miles per hour would have a duration of 60 seconds, a fastest mile wind speed of 50 miles per hour would have a duration of 72 seconds, etc.

Table 2-3: Annual Extreme Wind Speed (mph) Per Direction for BWI Airport, 1951-1982

Year	North	Northeast	East	Southeast	South	Southwest	West	Northwest
1951	24	41	27	34	39	29	42	46
1952	66	25	47	66	41	66	46	43
1953	20	28	22	27	34	39	47	43
1954	31	27	22	60	28	39	57	44
1955	21	43	29	28	43	53	40	43
1956	29	34	25	24	28	34	56	40
1957	29	53	35	33	33	30	46	46
1958	30	52	25	33	37	43	40	43
1959	28	26	20	27	23	38	46	43
1960	26	38	28	27	25	35	40	53
1961	45	28	28	29	24	70	41	54
1962	56	41	28	17	25	36	42	61
1963	38	32	18	34	25	28	44	60
1964	34	31	23	24	47	23	48	61
1965	36	26	28	34	36	54	44	44
1966	32	25	29	24	47	43	50	48
1967	30	29	25	39	27	46	53	43
1968	45	30	36	26	19	45	48	50
1969	28	21	20	34	26	45	45	53
1970	28	28	18	21	39	34	48	60
1971	31	45	26	18	21	41	39	58
1972	28	25	35	26	20	41	41	41
1973	40	26	26	38	26	35	49	33
1974	32	23	46	29	33	33	45	41
1975	40	26	21	24	25	38	54	45
1976	31	18	20	28	32	28	45	54
1977	32	31	19	28	26	25	49	48
1978	39	28	36	28	19	52	33	45
1979	32	25	27	36	32	32	45	47
1980	33	27	18	32	20	32	45	50
1981	24	24	19	26	23	28	41	42
1982	31	20	23	23	29	34	40	48

Note: Data adjusted to 10 meter height.

2.6.2 Wave Conditions

James Island is exposed to wind-generated waves approaching from all directions. In accordance with procedures recommended by the USACE, Shore Protection Manual (SPM) (USACE, 1984), a radially averaged fetch distance was computed for the eight directions, namely N, NE, E, SE, S, SW, W and NW. The radially averaged fetch distances for these directions are shown in Table 2-4 and Figure 2-5.

Table 2-4: Radial Fetch Distance and Mean Water Depth at James Island

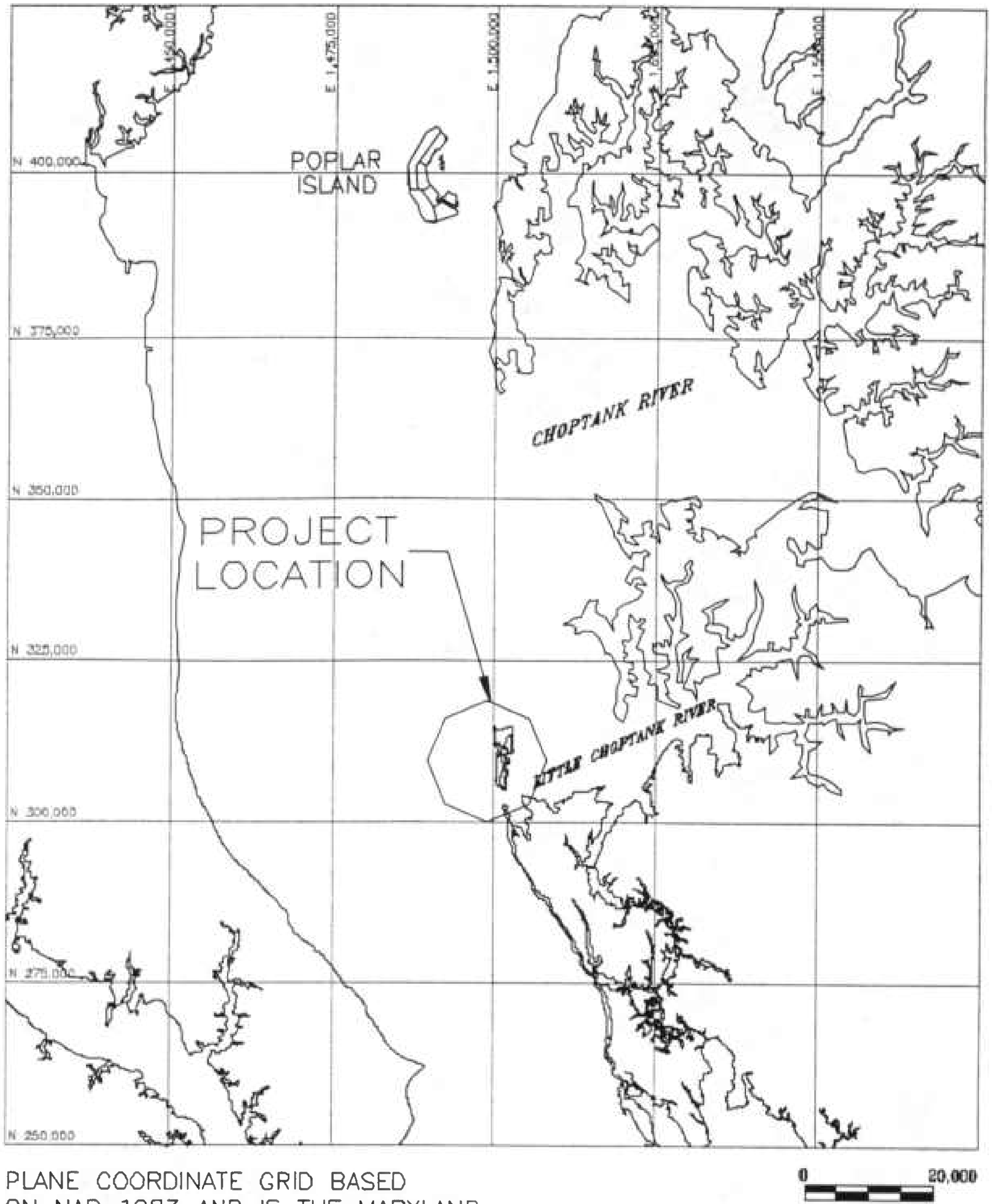
Direction	Mean Distance (Miles)	Mean Water Depth (ft, MLLW)
North	26.9	34.2
Northeast	5.3	9.6
East	5.3	12.2
Southeast	2.4	3.7
South	29.5	43.1
Southwest	6.9	39.8
West	8.3	35.4
Northwest	8.0	28.5

Wave conditions were hindcast along each fetch direction for the design winds presented in Table 2-3 (adjusted appropriately for duration) and the mean water depths along the fetch directions as shown in Table 2-4 using methods published in the SPM (1984). Wave hindcast results are presented in Figure 2-6 (Significant Wave Height, H_s) and Figure 2-7 (Peak Wave Period, T_p). These figures present a summary of H_s and T_p showing the directions from which the highest waves and longest periods approach the site.

2.7 SITE SOIL CHARACTERISTICS

An evaluation of the soil characteristics at the project site was performed by Engineering

Consultation Construction Remediation, Inc. (E2CR, 2002). The evaluation included performing soil borings, preparing soil boring profiles, identifying soil strata thickness, location and characteristics, and conducting a preliminary slope stability analysis. Results of the preliminary study indicate that the underlying soil consists of silty sand suitable for supporting a dike. Areas with soft silty clays at the mud line, however, would need to be undercut and backfilled with sand.



PLANE COORDINATE GRID BASED
ON NAD 1983 AND IS THE MARYLAND
STATE COORDINATE GRID SYSTEM

Figure 2-1: James Island Location Map

Figure 2-2: James Island August 2002 Aerial Photograph Looking Southeast

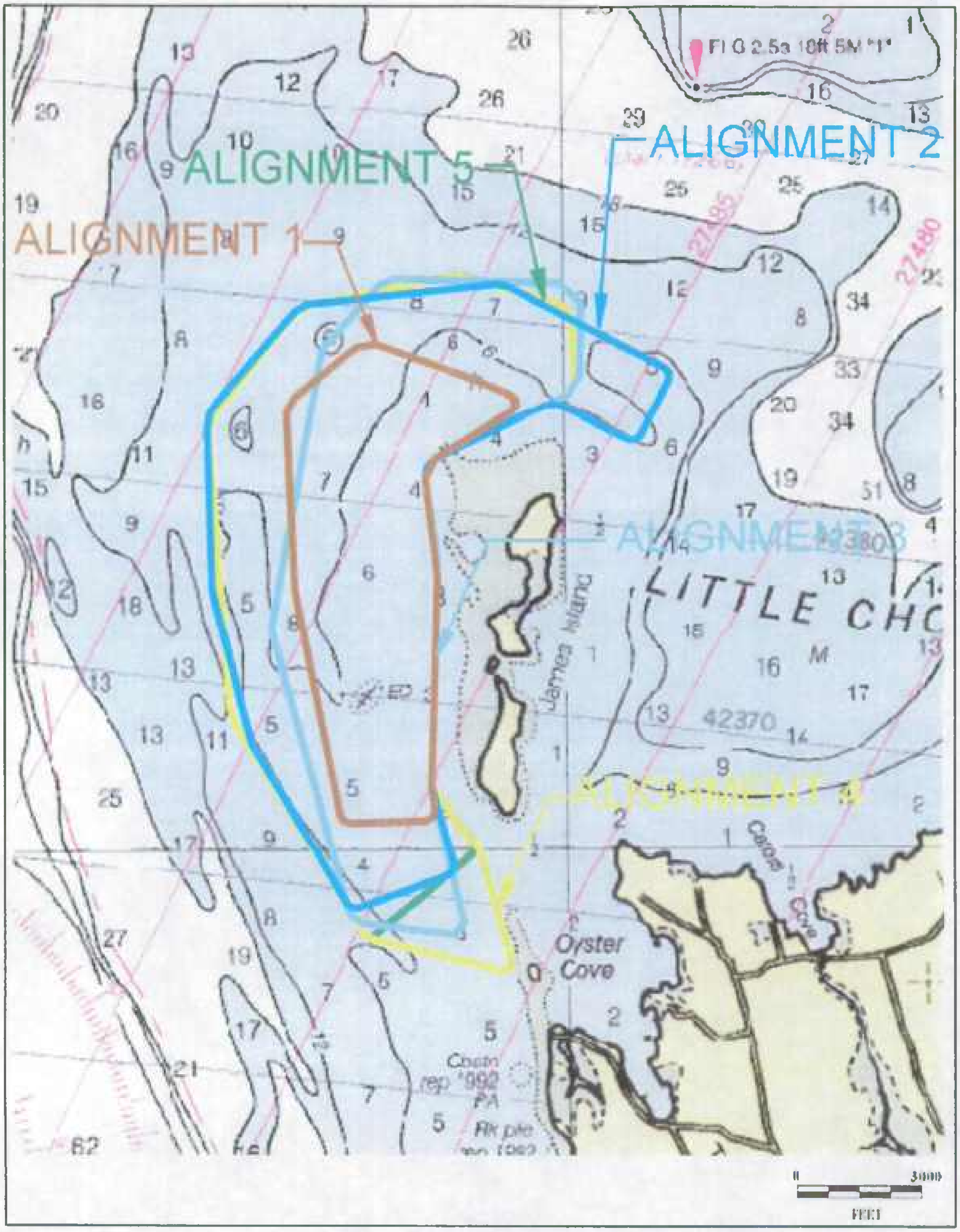


Figure 2-3: James Island Five Alignments and Surro unding Bathymetry

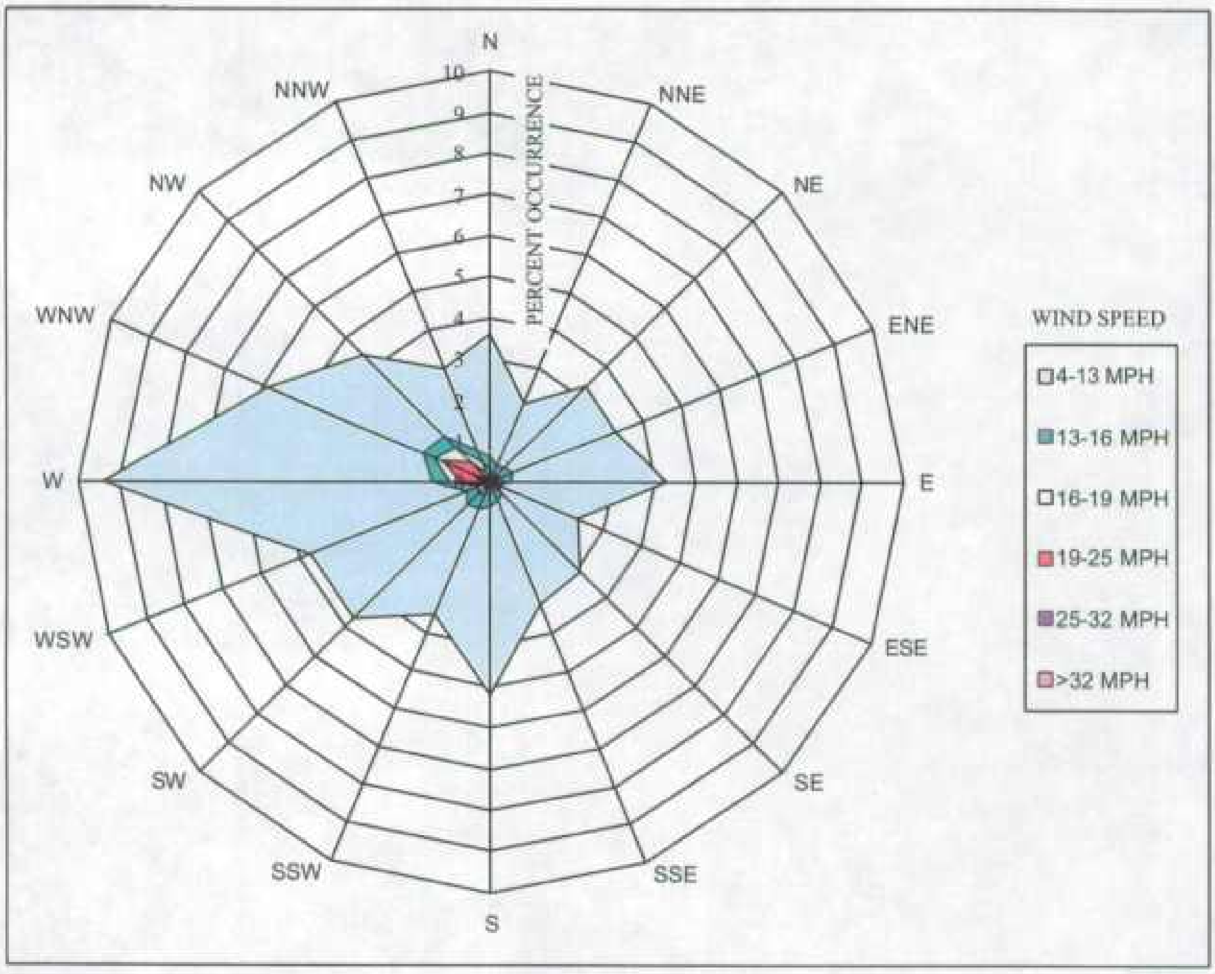


Figure 2-4: Baltimore-Washington International Airport (BWI) Wind Rose

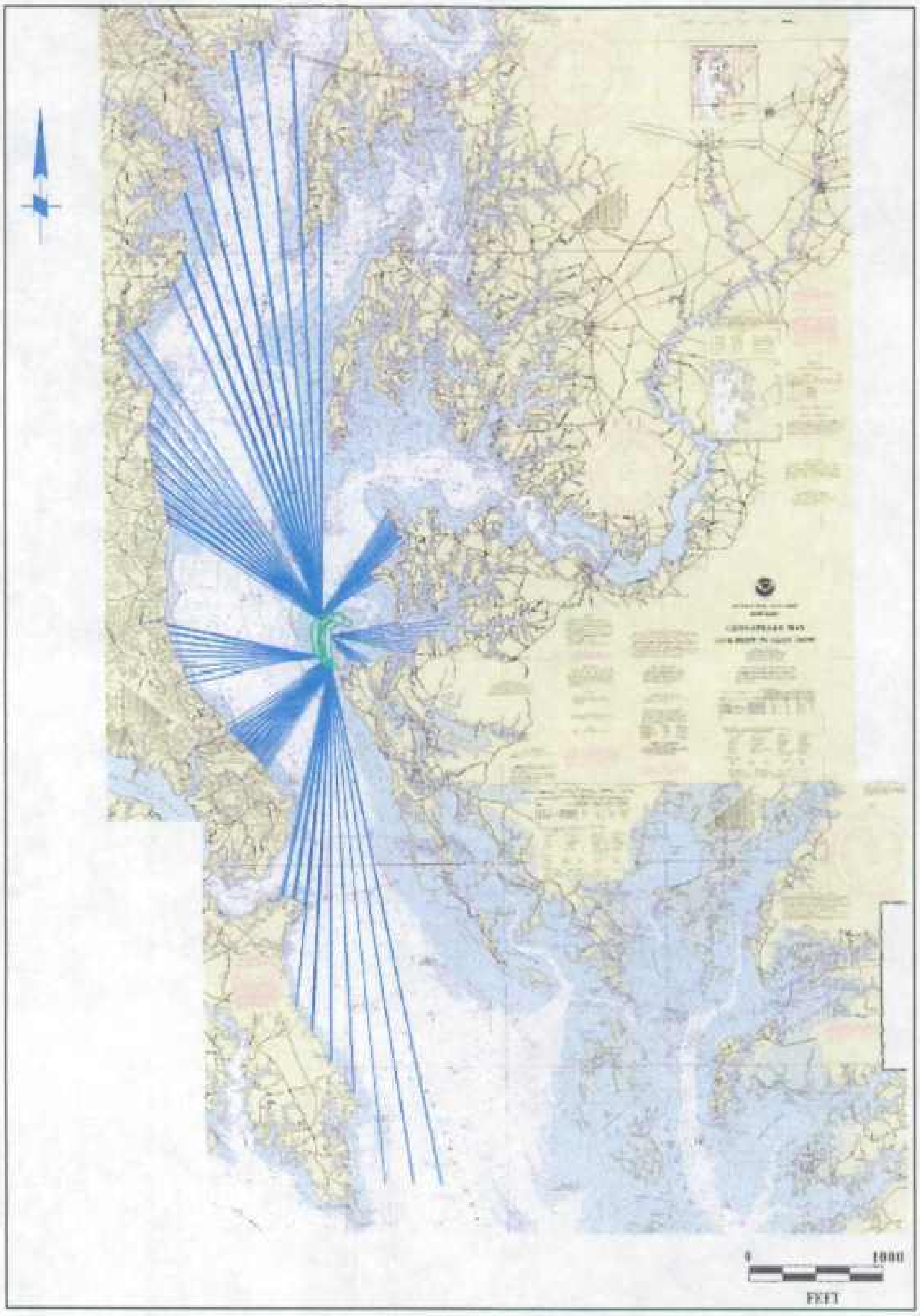


Figure 2-5: James Island Radially-Averaged Fetch Distances

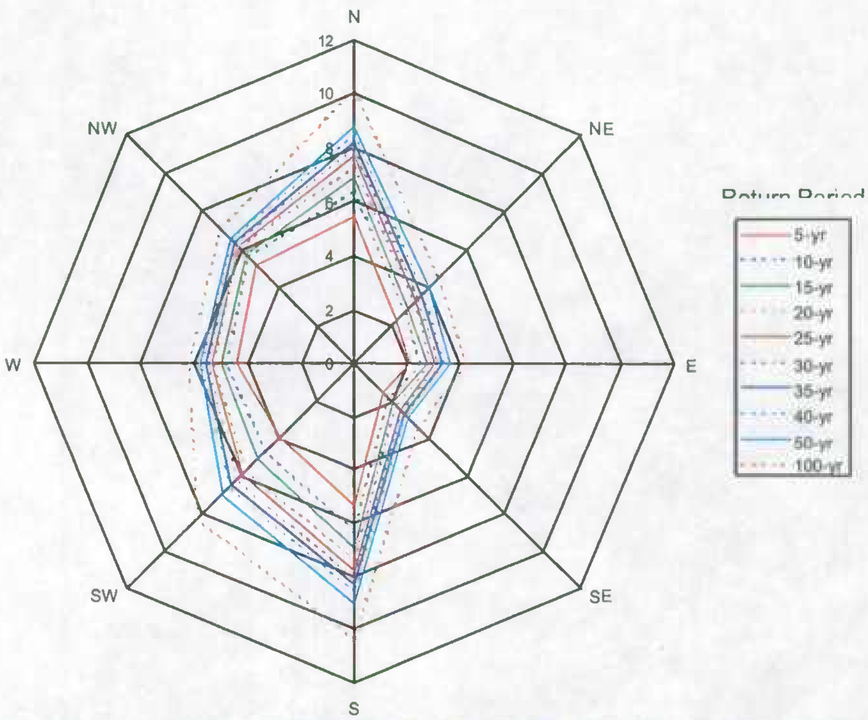


Figure 2-6: Offshore Significant Wave Heights (ft) for James Island

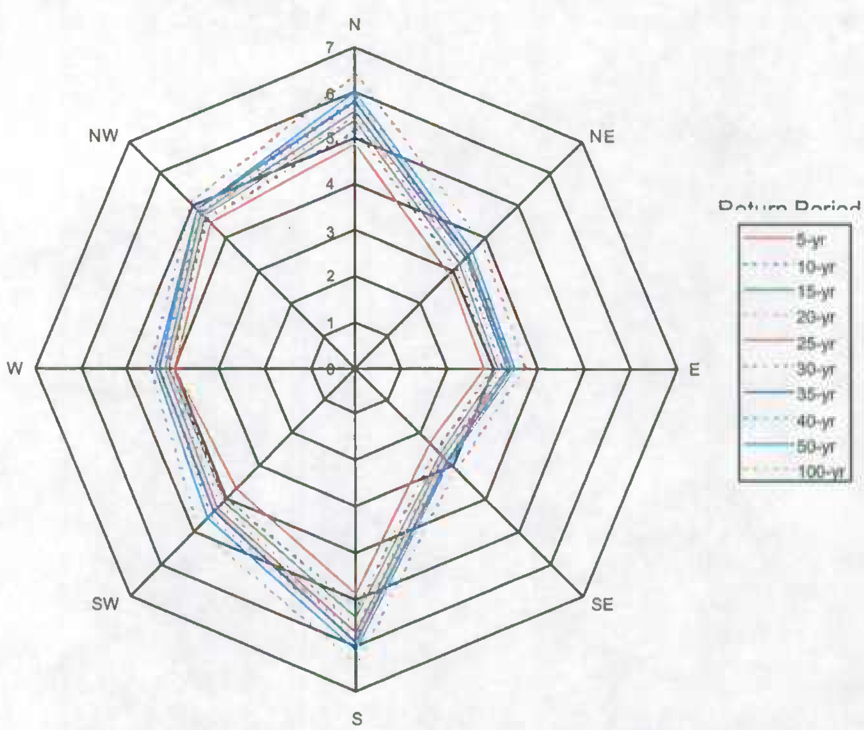


Figure 2-7: Peak Spectral Wave Periods (sec) for James Island

3. SIMULATION MODELS

3.1 GENERAL

The numerical modeling system used in this study is the USACE, Waterways Experiment Station (WES) finite element hydrodynamics (RMA-2) and sedimentation (SED-2D) models – collectively known as TABS-2 (Thomas et al., 1985). TABS-2 is a collection of generalized computer programs and pre- and post-processor utility codes integrated into a numerical modeling system for studying two-dimensional depth-averaged hydrodynamics, constituent transport, and sedimentation problems in rivers, reservoirs, bays, and estuaries. The finite element method provides a means of obtaining an approximate solution to a system of governing equations by dividing the area of interest into smaller sub-areas called elements.

Time-varying partial differential equations are transformed into finite element form and then solved in a global matrix system for the modeled area of interest. The solution is smooth across each element and continuous over the computational area. This modeling system is capable of simulating wetting and drying of marsh and intertidal areas of the estuarine system.

A schematic representation of the system is shown in Figure 3-1. It can be used either as a stand-alone solution technique or as a step in the hybrid modeling approach. The model calculates water surface elevations, current patterns, constituent transport, sediment erosion and deposition, the resulting bed surface elevations, and the feedback to hydraulics. Existing conditions can be analyzed to determine the impacts of project construction at James Island on flow circulation and sedimentation. All models are depth-averaged and are solved by the finite element method using Galerkin weighted residuals.

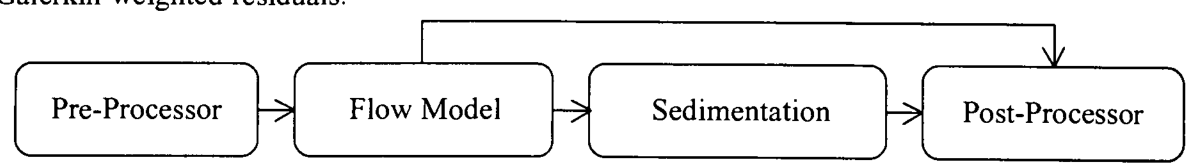


Figure 3-1: TABS-2 Schematic

3.2 HYDRODYNAMIC MODEL

RMA-2 is a two-dimensional, depth-averaged, finite element, hydrodynamic numerical model. It computes water surface elevations and horizontal velocity components for subcritical, free-surface flow in two dimensional flow fields. RMA-2 computes a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated with the Manning's or Chezy equation, and eddy viscosity coefficients are used to define turbulence characteristics. The equations also account for Coriolis forces and surface wind stresses. Both steady and unsteady state (dynamic) problems can be analyzed. The general governing equations are:

$$h\frac{\partial u}{\partial t}+hu\frac{\partial u}{\partial x}+hv\frac{\partial u}{\partial y}-\frac{h}{\rho}\left(E_{xx}\frac{\partial^2 u}{\partial x^2}+E_{xy}\frac{\partial^2 u}{\partial y^2}\right)+gh\left(\frac{\partial a}{\partial x}+\frac{\partial h}{\partial x}\right)+\frac{gun^2}{\left(1.486h^{1/6}\right)^2}+$$
$$(u^2+v^2)^{1/2}-\zeta V_a^2\cos\psi-2h\omega v\sin\phi=0$$

$$h\frac{\partial v}{\partial t}+hu\frac{\partial v}{\partial x}+hv\frac{\partial v}{\partial y}-\frac{h}{\rho}\left(E_{yx}\frac{\partial^2 v}{\partial x^2}+E_{yy}\frac{\partial^2 v}{\partial y^2}\right)+gh\left(\frac{\partial a}{\partial y}+\frac{\partial h}{\partial y}\right)+\frac{gvn^2}{\left(1.486h^{1/6}\right)^2}+$$
$$(u^2+v^2)^{1/2}-\zeta V_a^2\sin\psi-2h\omega v\sin\phi=0$$

$$\frac{\partial h}{\partial t}+h\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)+u\frac{\partial h}{\partial x}+v\frac{\partial h}{\partial y}=0$$

where:

h = Depth

u,v = Velocities in Cartesian directions

x,y,t = Cartesian coordinates and time

ρ = Density of fluid

E = Eddy viscosity coefficient

for xx = normal direction on x-axis surface

for yy = normal direction on y-axis surface

for xy and yx = shear direction on each surface

g = Acceleration due to gravity

a = Elevation of Bottom

n = Manning's roughness n-value

1.486 = Conversion from SI (metric) to non-SI units

ζ = Empirical wind shear coefficient

V_a = Wind speed

Ψ = Wind direction

ω = Rate of Earth's angular rotation

ϕ = Local latitude

RMA-2 operates under the hydrostatic assumption, meaning accelerations in the vertical direction are negligible. RMA-2 is two dimensional in the horizontal plane and is not intended for use in near-field problems where vortices, vibrations, or vertical accelerations are of primary interest. Vertically stratified flow effects are beyond the capabilities of RMA-2.

3.3 SEDIMENTATION MODEL

The sedimentation model, SED-2D, can be applied to sediments where flow velocities can be considered two-dimensional in the horizontal plane (i.e., the speed and direction can be satisfactorily represented as a depth-averaged velocity). It is useful for both deposition and erosion studies. The program treats two categories of sediment: 1) noncohesive, which is referred to as sand herein; and 2) cohesive, which is referred to as clay.

Both clay and sand may be analyzed, but the model considers a single, effective grain size during each simulation. Therefore, a separate model run is required for each effective grain size. Settling velocity must be prescribed along with the water surface elevations, x-velocity, y-velocity, diffusion coefficients bed density, critical shear stresses for erosion, erosion rate constants, and critical shear stress for deposition.

The derivation of the basic finite element formulation is presented in Ariathurai (1974) and Ariathurai, MacArthur, and Krone (1977) and is summarized below.

There are four major computations.

1. Convection-Diffusion Governing Equation
2. Bed Shear Stress Calculation
3. The Bed Source/Sink Term
4. The Bed Strata Discretization

3.3.1 Convection-Diffusion Governing Equation

The mesh employed for the hydrodynamic model is used for the sedimentation model. The convection-dispersion equation in two horizontal dimensions for a single sediment constitute solved by the model is:

$$\frac{\partial C}{\partial t}+u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D_x\frac{\partial^2 C}{\partial x^2}+D_y\frac{\partial^2}{\partial y^2}+\alpha_1^C+\alpha_2$$

where:

u,v	=	depth-averaged sediment velocity components
C	=	suspended sediment concentration
D_x	=	effective diffusion coefficient in X-direction
D_y	=	effective diffusion coefficient in Y-direction
α_1	=	concentration-dependent source/sink term
α_2	=	coefficient of source/sink term

The source/sink terms in the above equation are computed in routines that pertain to the interaction of the flow and the bed. Separate sections of the code handle computations for clay bed and sand bed problems as described below.

3.3.2 Bed Shear Stress

Bed shear stresses are calculated from the flow speed according to one of four optional equations: the smooth-wall log velocity profile or Manning equation for flows alone; and a smooth bed or rippled bed equation for combined currents and wind waves. Shear stresses are calculated using the shear velocity concept where

$$\tau_b = \rho u_*^2$$

where:

τ_b = bed shear stress

u_* = shear velocity

and the shear velocity is calculated by one of four methods:

a. Smooth-wall log velocity profiles

$$\frac{\bar{u}}{u_*} = 5.75 \log\left(3.32 \frac{u_* h}{\nu}\right)$$

which is applicable to the lower 15 percent of the boundary layer when

$$\frac{u_* h}{\nu} > 30$$

where $\bar{u}$ is the mean flow velocity (resultant of u and v components)

b. The Manning shear stress equation

$$u_* = \frac{(\bar{u}n)\sqrt{g}}{CME(h)^{1/6}}$$

where CME is a coefficient of 1 for SI (metric units) and 1.486 for non-SI units of measurement.

c. A Jonsson-type equation for surface shear stress (plane beds) caused by waves and currents

$$u_* = \sqrt{\frac{1}{2}\left(\frac{f_w u_{om} + f_c \overline{u}}{u_{om} + u}\right)\left(\overline{u} + \frac{u_{om}}{2}\right)}$$

where

f_w = shear stress coefficient for waves

u_{om} = maximum orbital velocity of waves

f_c = shear stress coefficient for currents

d. A Bijker-type equation for total shear stress caused by waves and current

$$u_* = \sqrt{\frac{1}{2} f_c \overline{u}^2 + \frac{1}{4} f_w u_{om}^2}$$

3.3.3 Source/Sink Terms

The Ackers-White (1973) procedure is used to calculate a sediment transport potential for sand from which actual sand transport is calculated based on sediment availability. Model clay erosion is based on formulas by Partheniades (1962) and Ariathurai while the deposition of clay utilizes Krone's equations (Ariathurai, MacArthur, and Krone, 1977).

3.3.3.1 Sand Transport

For sand transport, the transport potential of the flow and availability of material in the bed control the supply of sediment from the bed. The bed source term is

$$S = \frac{C_{eq} - C}{t_c}$$

where:

S = source term

C_{eq} = equilibrium concentration (transport potential)

C = sediment concentration in the water column

t_c = characteristic time for effecting the transition

There are many transport relations for calculating C_{eq} for sand size material. The Ackers-White (1973) formula performed satisfactorily in tests by WES and others (White, Milli, and Crabbe 1975; Swart1976) and was thus adopted for this model. The transport potential is related to sediment and flow parameters by the expressions in the following paragraphs. The Ackers-White formula computes the total load, including suspended load and bed load, and was developed originally for fine sand. The formulation was later updated to include coarser sands and these revised coefficients are included in the current model formulation. However, the appropriateness of the use of SED-2D with the Ackers-White formula diminishes with coarsening of the sediment. The Ackers-White procedure is as follows:

$$P_{ei} g_s = P_{bi} G_{gri} \gamma_s U \frac{(U)^b}{u_*} D_i$$

$$g_s = G_{gri} \gamma_s U \left(\frac{U}{u_*} \right)^b D_m$$

$$G_{ri} = \left\{ a \left(\frac{F}{A} - 1 \right)^m \right\} for \quad D_m = D_i$$

$$F = \left(\frac{u_*^{\,b}}{\sqrt{g D_m (\gamma_g - 1)}} \right) \left(\frac{U^{1-b}}{\sqrt{32} \log\left(\frac{10R}{D_m} \right)} \right)$$

$$D_g = D_m \frac{\left[g(\gamma_g - 1) \right]^{1/3}}{v^2}$$

Value of a:

$$a = 0.025 \; for \; D_g > 60$$

$$\log a = 2.86 \log D_g - (\log D_g)^2 - 3.53 \; for \; 60 \geq D_g > 1$$

Value of b:

$$b = 0.0 \; for \; D_g > 60$$

$$b = 1 - 0.56 \log D_g \; for \; 60 \geq D_g > 1$$

Value of A:

$$A = 0.17 \; for \; D_g > 60$$

$$A = \frac{0.23}{\sqrt{D_g}} + 0.14 \; for \; 60 \geq D_g > 1$$

Value of m:

$$m = 1.50 \; for \; D_g > 60$$

$$m = \frac{9.66}{\sqrt{D_g}} + 1.34 \; for \; 60 \geq D_g > 1$$

where:

P_{ei} = Percentage of grain-size D_i transported

g_s = transport rate for uniform sediment of size D_m

P_{bi} = Percentage of grain-size D_i for bed materials

$?_s$ = Specific gravity of sediment particle

U = Average flow velocity

u_* = Shear velocity on riverbed

D_g = Dimensionless grain-size

D_m = Sediment particle-size

R = Hydraulic radius

The characteristic time, t_c, is somewhat subjective. It should be the amount of time required for the concentration in the flow field to change from C to C_{eq}. In the case of deposition, t_c is related to fall velocity. The following expression was adopted.

$$t_c = \text{the larger of} \begin{cases} C_d \dfrac{h}{V_s} \\ or \\ DT \end{cases}$$

where:

t_c = Characteristic time

C_d = Coefficient for deposition

V_s = Fall velocity of a sediment particle

DT = Computational time interval

In the case of scour, there are no simple parameters to employ. The following expression is used.

$$t_c = \text{the larger of} \begin{cases} C_e \dfrac{h}{\overline{u}} \\ or \\ DT \end{cases}$$

where:

C_e = Coefficient for entrainment

V = Flow speed

3.3.3.2 Clay Transport

Cohesive sediments (usually clays and some silts) are considered to be depositional if the bed shear stress exerted by the flow is less than a critical value τ_d. When that value occurs, the deposition rate is given by Krone's (1962) equation:

$$S = \begin{cases} -\dfrac{2V_s}{h} C\left(1 - \dfrac{\tau}{\tau_d}\right) \text{for } C < C_c \\ -\dfrac{2V_s}{hC_c^{4/3}} C^{5/3}\left(1 - \dfrac{\tau}{\tau_d}\right) \text{for } C > C_c \end{cases}$$

where:

S	=	source term
V_s	=	fall velocity of a sediment particle
h	=	flow depth
C	=	sediment concentration in water column
τ	=	bed shear stress
τ_d	=	critical shear stress for deposition
C_c	=	critical concentration = 300 mg/ ℓ

If the bed shear stress is greater than the critical value for particle erosion τ_e, material is removed from the bed. The source term is then computed by Ariathuarai's (Ariathurai, MacArthur, and Krone 1977) adaptation of Partheniades' (1962) findings:

$$S = \frac{P}{h}\left(\frac{\tau}{\tau_e} - 1\right) \text{for } \tau > \tau_e$$

where P is the erosion rate constant, unless the shear stress is also greater than the critical value for mass erosion. When this value is exceeded, mass failure of a sediment layer occurs and

$$S = \frac{T_L \rho_L}{h\Delta t} \text{ for } \tau > \tau_s$$

where:

T_L = thickness of the failed layer

ρ_L = density of the failed layer

Δt = time interval over which failure occurs

τ_s = bulk shear strength of the layer

3.3.4 Bed Strata Discretization

The source-sink term in convection-diffusion equation becomes a source-sink term for the bed model, which keeps track of the elevation, composition, and character of the bed.

3.3.4.1 Sand Beds

Sand beds are considered to consist of a sediment reservoir of finite thickness, below which is a nonerodible surface. Sediment is added to or removed from the bed at rate determined by the value of the source-sink term at the previous and present time-steps. The mass rate of exchange with the bed is converted to a volumetric rate of change by the bed porosity parameter.

3.3.4.2 Clay Beds

Clay beds are treated as a sequence of layers. Each layer has its own characteristics as follows:

- Thickness.
- Density.
- Age.
- Bulk shear strength.
- Type.

In addition, the layer type specifies a second list of characteristics.

- Critical shear stress for erosion.
- Erosion rate constant.
- Initial and 1-year densities.
- Initial and 1-year bulk shear strengths.

- Consolidation coefficient.
- Clay or sand.

New clay deposits form layers up to a specified initial thickness and then increase in density and strength with increasing overburden pressure and age. Variation with overburden occurs by increasing the layer type value by one for each additional layer deposited above it.

4. FINITE ELEMENT MESH

4.1 GENERAL

The numerical modeling system implemented herein requires that a database of water depths and bottom material properties represent the estuarial system. Water depths are represented by nodes located in the horizontal plane, which are interconnected to create elements. Two, three, or four nodes can be connected to form elements. The resulting nodal/element network is commonly called a finite element mesh and provides a computerized representation of the estuarial geometry and bathymetry.

4.2 ELEMENTS

RMA-2 is capable of supporting different types of elements within the same computational finite element mesh. The types of elements fit into three basic categories:

- Two Dimensional Elements
- One Dimensional Elements
- Special Elements

These element types are discussed briefly in the following sections.

4.2.1 Two Dimensional Elements

Two-dimensional elements are the customary type used with RMA-2 and may be either triangular or quadrilateral in shape, as shown in Figure 4-1. A two dimensional element possesses a length and a width, determined by the positions of the corner nodes which define the element. The depth at any location within a two dimensional element is obtained by interpolating among the depths of the corner nodes which define the element.

Figure 4-1: Finite Element Shapes

4.2.2 One Dimensional Elements

A one-dimensional element is a simplified element which is composed of two corner nodes and one midside node. The Finite Element Governing Equations for one-dimensional elements are based on a trapezoidal cross section with side slopes, and an off channel storage area. The depth at any location along a one-dimensional element is obtained by interpolating between the depths of the two corner nodes defining the element.

4.2.3 Special Elements

Special elements are one-dimensional elements that serve special purposes including transition from one- to two-dimensional elements, junctions between multiple one-dimensional elements, and flow control structures.

4.3 MODEL EXTENTS

The areal extent and the level of detail necessary to represent the project area are the parameters that define a finite element mesh. The TABS-2 system, described in Section 3.0, is numerically robust and capable of simulating tidal elevations, flows, and sediment transport over a mesh with widely varying boundaries and levels of detail. Accordingly, the incorporation of significant bathymetric features of the estuary generally dictates the level of detail for the mesh. However, there are several factors used to guide decisions regarding the extents of the mesh. First, it is desirable to extend the mesh to areas sufficiently distant from the project site such that the boundary conditions do not directly influence the hydrodynamics at the site. Secondly, the terminus of the mesh should be in a location where conditions can be reasonably measured and described to the model. Additionally, it is preferable to locate boundaries in locations where flow characteristics have been measured or are known and can be accurately specified.

Geometric information for the UCB-FEM model was obtained from NOAA Digital Elevation Models (DEMs), nautical charts, and recently performed bathymetric surveys. NOAA DEM's are electronic maps of bathymetric elevations imposed on a 30-meter grid and are based on many years of hydrographic survey data acquired for production of navigational charts. For the areas not covered by the DEM, navigation charts were used to complete the mesh. The resulting mesh geometry was checked and alterations were made as deemed necessary to improve physical representation of the estuary and to improve model stability in areas of large depth gradients.

The UCB-FEM model finite element mesh used herein is shown in Figure 4-2. Quadrilateral and triangular 2-dimensional elements were used to represent the estuarial system. The southern boundary of the mesh is located in the Chesapeake Bay near the Hooper Island Light from which it extends north to its terminus at the Conowingo Dam on the Susquehanna River and Chesapeake City on the C & D Canal resulting in total mesh length of roughly 90 nautical miles. A dense mesh was created around James Island to provide a more accurate simulation of conditions at the project site.

Water depths were adjusted to represent both existing and with-project conditions. Figure 4-3 depicts the finite element mesh developed for existing conditions in the vicinity of James Island. Figures 4-4 through 4-8 depict the finite element meshes developed for Alignments 1 through 5, respectively.

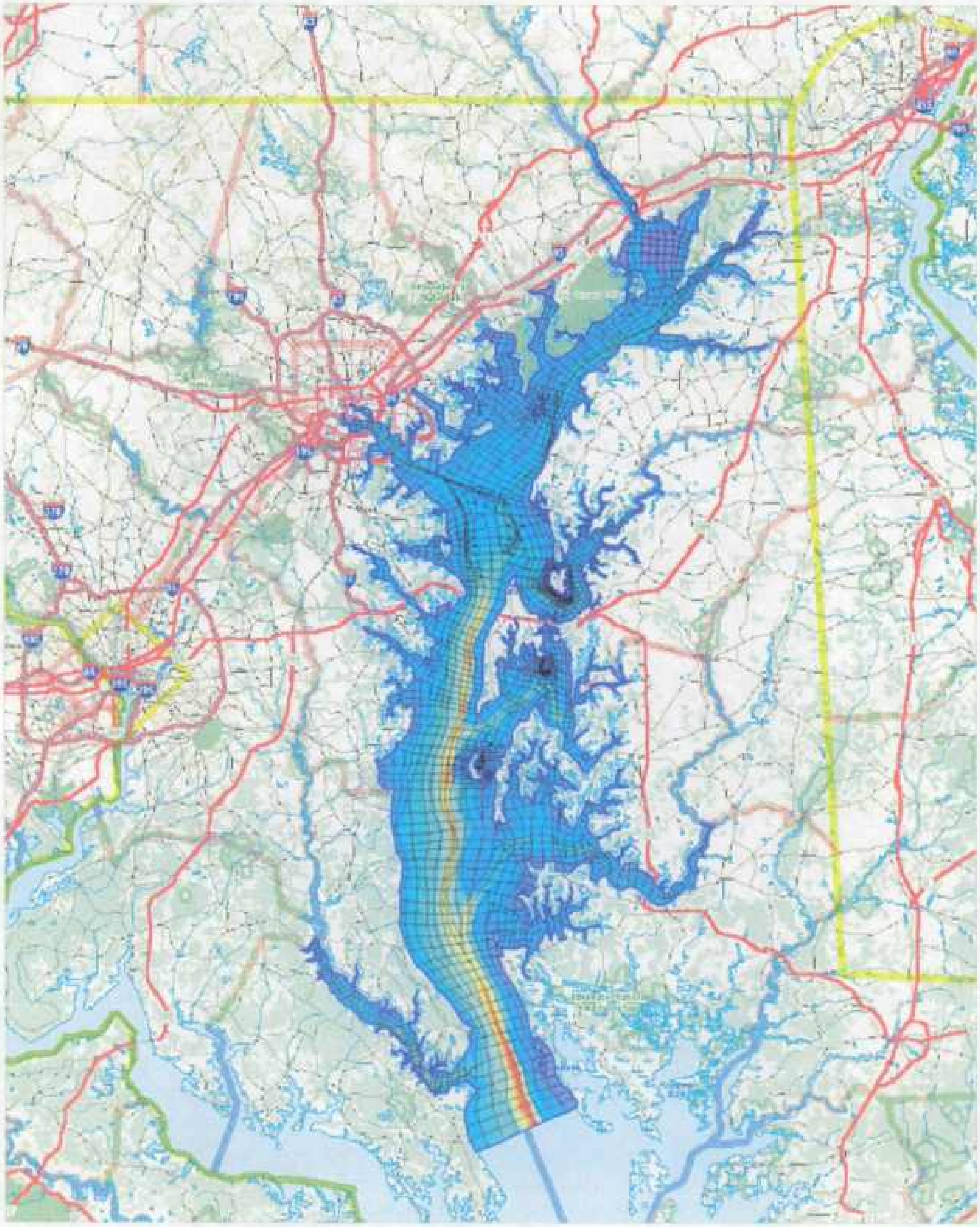


Figure 4-2: Upper Chesapeake Bay Finite Element Model (UCB-FEM)

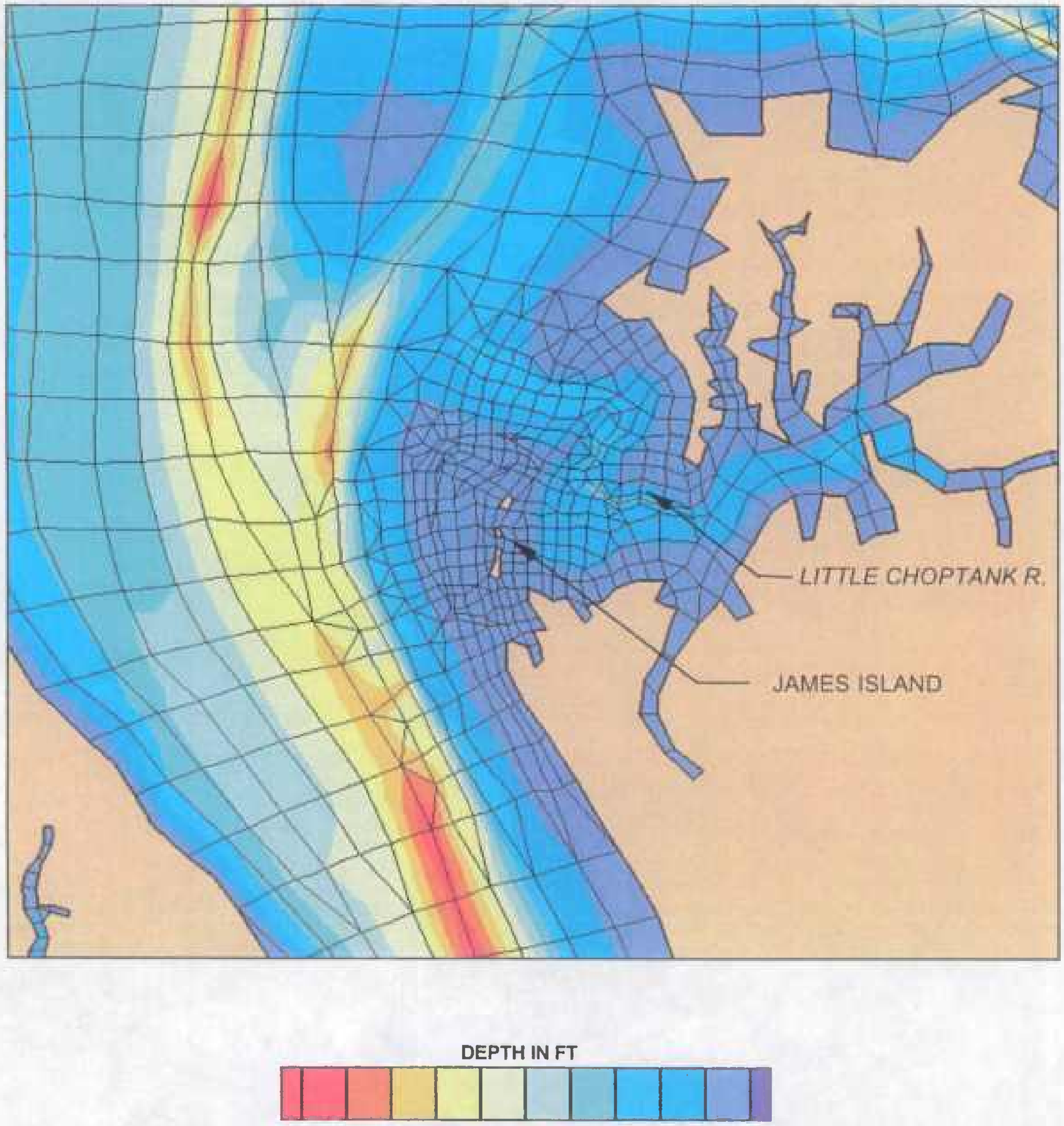


Figure 4-3: UCB-FEM – James Island Existing Conditions

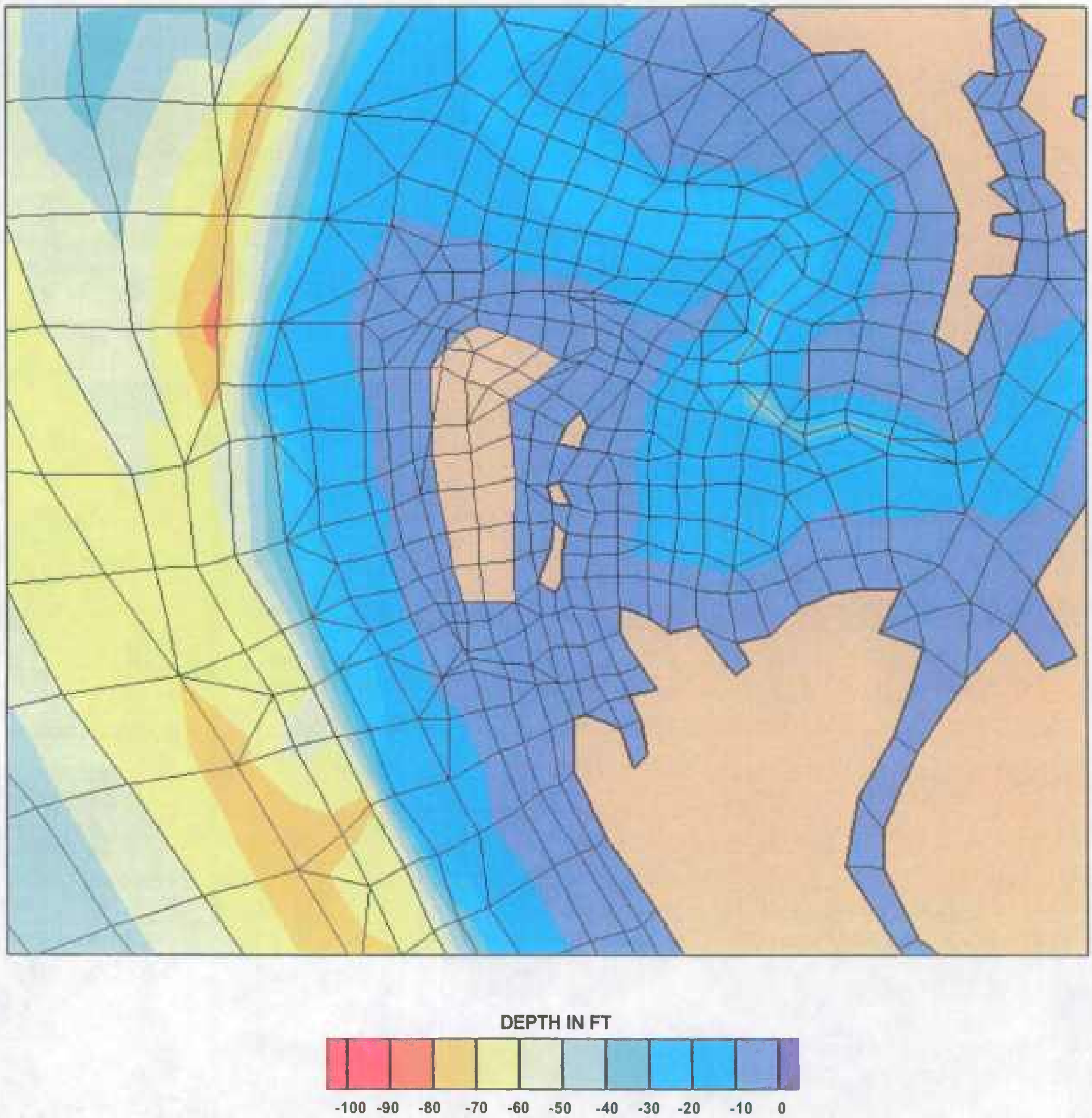


Figure 4-4: UCB-FEM – James Island Alignment 1

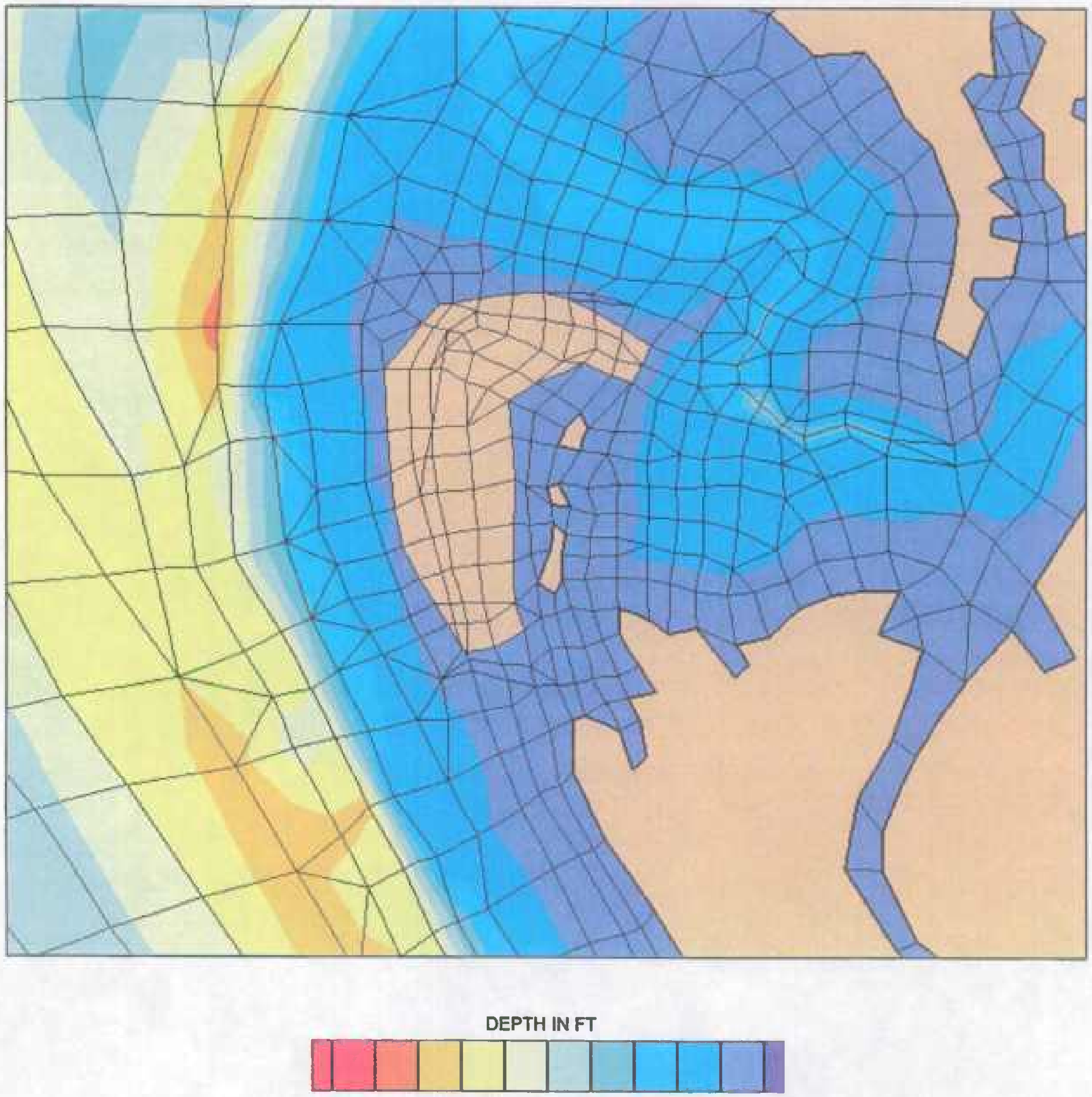


Figure 4-5: UCB-FEM – James Island Alignment 2

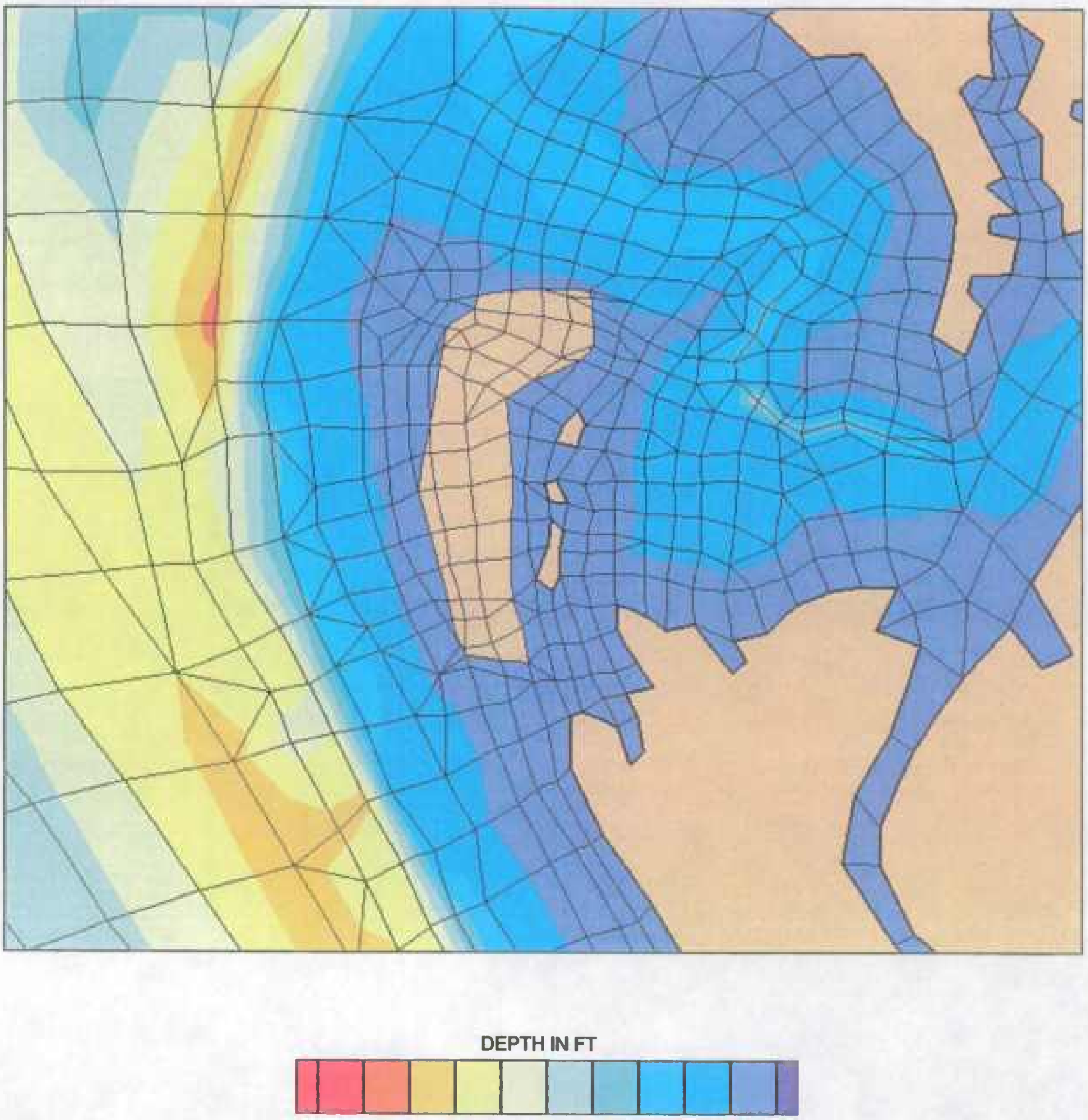


Figure 4-6: UCB-FEM – James Island Alignment 3

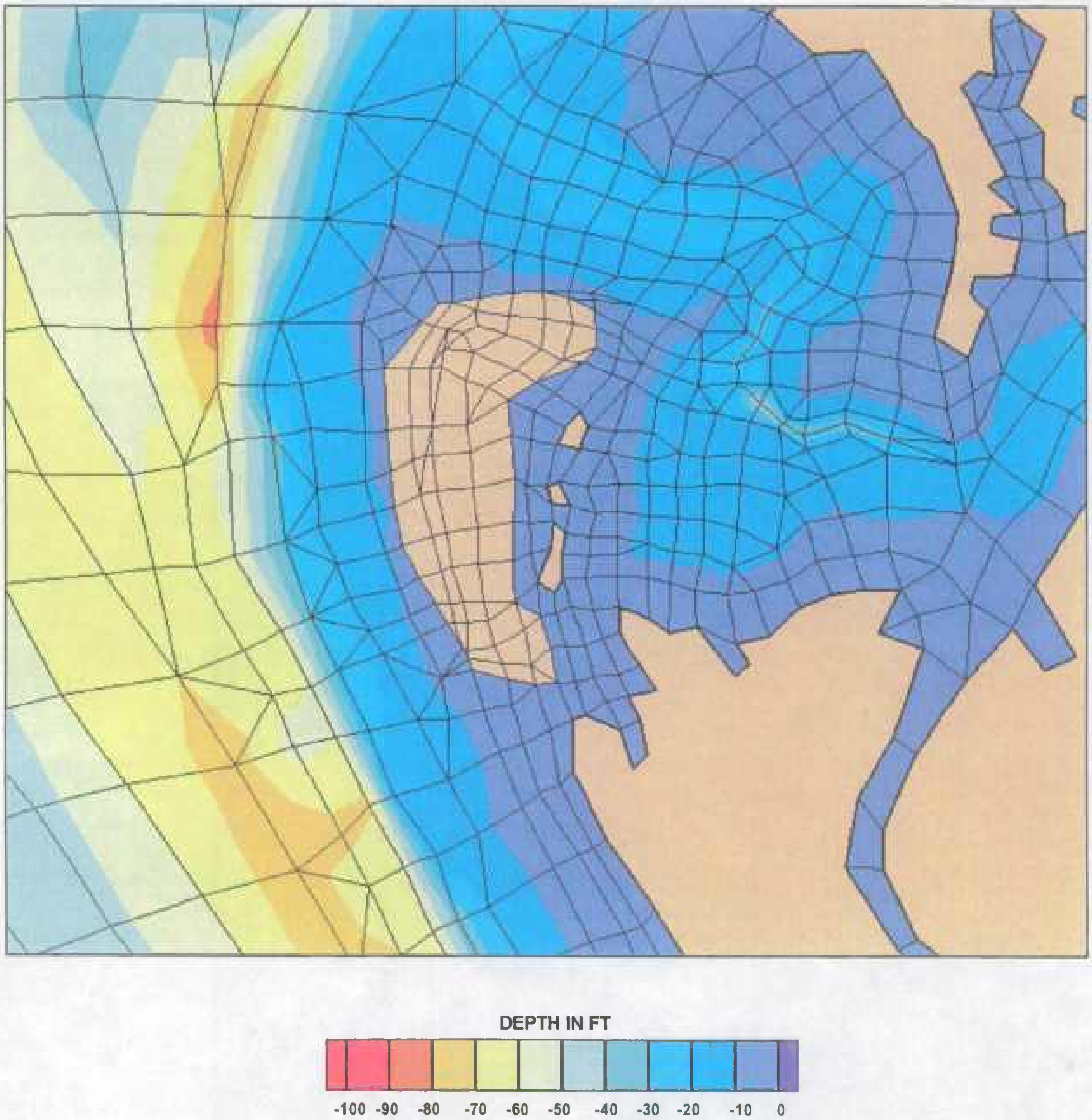


Figure 4-7: UCB-FEM – James Island Alignment 4

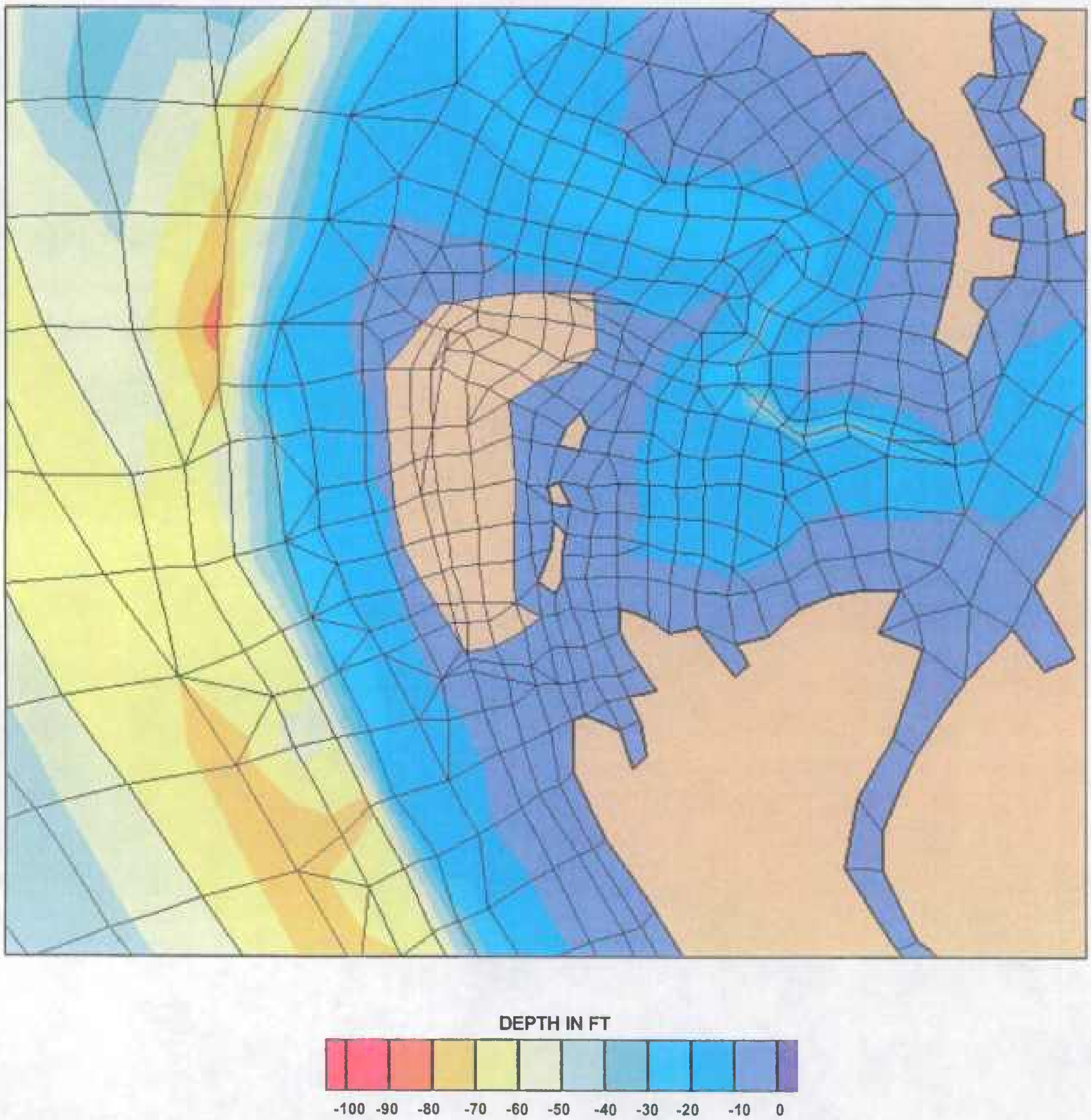


Figure 4-8: UCB-FEM – James Island Alignment 5

5. MODEL CALIBRATION

5.1 GENERAL

A measure of a finite element model's accuracy is the comparison of modeled tide elevations and currents with measured or known values. A properly calibrated model can be expected to produce current velocity and tidal elevation results with 80% to 100% accuracy. Model calibrations are adjusted by the refinement of the model bathymetry, the accurate representation of bottom structure (i.e. vegetation, mud, sand) and the stipulation of model parameters that are artifacts of the numerical formulation and are functions of element size and empirical constants. Upon satisfactory completion of calibration, the model can be used to evaluate the impacts of physical changes to the system.

Model calibration is best achieved by means of a set of simultaneous measurements both along the model boundaries and throughout the estuarial system. Boundary conditions important to the present study include tidal elevation, flow velocity, freshwater discharge, suspended sediment concentration, and bottom change over time. For a given set of boundary conditions, the model should be calibrated to reproduce tidal elevations, tidal velocities, or sedimentation rates and patterns within the estuary. The sediment transport model is driven by results obtained from the hydrodynamic model; therefore, the latter is calibrated first.

5.2 HYDRODYNAMIC MODEL

The UCB-FEM model is controlled by boundary conditions as shown in Figure 5-1. Boundary condition values are either constant values or are variable time-dependent values. The major time-dependent boundary conditions are located on the southern boundary of the model in the vicinity of the Hooper Island Light, at the Conowingo Dam on the Susquehanna River and Chesapeake City on the C & D Canal on the northern boundaries. Additional time-dependent boundary conditions are stipulated at the Patuxent, Choptank and Chester Rivers. The values of the six time-dependent boundary conditions are shown in Figure 5-2. Constant flow values are used for boundary conditions for the Patapsco, Gunpowder, Bush and Elk Rivers. The values used at each of these boundaries are listed in Table 5-1.

The type of boundary condition is based on the data available at each boundary. The Hooper Island Light boundary condition is comprised of tidal elevations while the C & D Canal, Patuxent River, Chester River and Choptank River boundary conditions consist of current velocities and directions and the Conowingo Dam boundary condition is described by volume flux (flow). Boundary conditions located at smaller tributaries are described as constant sources of flow into the bay based on historic average measured flow. Calibration was performed for a two-week period of predicted data from February 1-14, 2001, which is representative of an average tidal cycle and low freshwater inflow.

Table 5-1: Freshwater Inflow Boundaries

Location	Flowrate (cfs)
Patapsco River	431
Gunpowder River	2888
Bush River	1149
Elk River	1874

Tide elevation and current velocity boundary conditions for the UCB-FEM model are based on NOS tidal predictions. NOS tidal predictions are based on historic harmonic constituents and represent idealized conditions which do not account for low frequency events including wind and storms. Figure 5-2 shows the water surface elevations and current velocities for the entire month of February 2001 at the boundary condition locations. The data used as boundary conditions in the UCB-FEM model calibration are for February 1 through February14.

Aside from the boundary conditions, the model is also influenced by bottom friction and eddy viscosity. Physically, bottom friction varies by bottom material and vegetation type and density and is best described by a map of Manning's roughness coefficient over the entire model domain. As is often the case, detailed information regarding bottom material is not available for the entire model domain. Standard practice is to then specify Manning's roughness relative to water depth resulting in a loose correlation with vegetation density. Eddy viscosity, or lateral mixing, also varies over the entire domain but is also dependent upon numerical element size and predicted current velocity in the model. Eddy viscosity is, therefore, specified based on a function calculated at each element for each time step. The final set of eddy viscosity and Manning's roughness values which provided the best fit between measured and simulated water elevations and flow velocities at measurement stations within the estuarial system were implemented.

NOS predicted tides and currents were used to check the model calibration at the locations shown in Figures 5-3 and 5-4. Figures 5-5 and 5-6 show results for selected calibration locations, for water surface elevations and current velocities, respectively.

Comparisons of the NOS predicted and UCB-FEM modeled data show excellent correlation to both tidal phasing and amplitudes. Tables 5-2 and 5-3 show the statistical comparison of the model results to NOS predicted data at each station subdivided by geographical regions. Statistics are calculated for overall calibration correlation and peak condition amplitudes. Percent error is calculated by dividing the RMS (root mean square) error by the calculated mean range.

Table 5-2: Water Surface Elevation Calibration Statistics

	Time Series Statistics		
	Correlation	**Peak RMS Error (ft)**	**Peak RMS Error %**
Little Choptank River			
Taylor's Island	100%	0.07	5.5%
Hudson Creek	98%	0.07	4.9%
Choptank River			
Broad Neck Creek	98%	0.06	4.3%
Choptank River Light	95%	0.05	3.4%
Cambridge	96%	0.08	5.1%
Choptank	92%	0.06	3.3%
Eastern Bay			
Claiborne	96%	0.10	9.0%
Miles River	99%	0.10	7.8%
Chester River			
Love Point	98%	0.10	8.7%
Cliff's Point	98%	0.09	5.8%
Sassafras and Susquehanna River and C and D Canal			
Betterton	92%	0.26	15.1%

Courthouse Point	99%	0.17	7.1%
Havre de Grace	92%	0.27	14.4%
Port Deposit	96%	0.44	19.6%
Main Chesapeake Bay			
Sharps Island Light	92%	0.07	5.1%
Poplar Island	95%	0.06	5.1%
Bloody Point Light	94%	0.07	6.4%
Matapeake	97%	0.12	12.3%
Pooles Island	94%	0.18	14.0%
Western Chesapeake Bay			
Cedar Point	100%	0.08	6.6%
Cove Point	100%	0.08	5.7%
Long Beach	96%	0.08	7.6%
Chesapeake Beach	97%	0.08	8.1%
West River	98%	0.14	14.6%
Thomas Light	96%	0.14	15.3%
Sandy Point	96%	0.20	25.2%
Seven Foot Knoll Light	96%	0.15	16.0%
Patapsco, Middle, and Gunpowder Rivers			
Fort Carroll	97%	0.10	8.8%
Rocky Point	95%	0.12	9.9%
Bowley's Bar	95%	0.16	12.5%
Battery Point	95%	0.14	11.3%

The model calibration results shown in Table 5-2 show better than 90% correlation for all locations. Predicted tidal elevation percent error is typically less than 10% with the exception of some specific areas of the model domain which are under 20%. Under-prediction of the Coriolis force and over-simplification of the bottom friction in the bay result in higher percent errors for tides along the western shore of the Bay including the Middle and Gunpowder Rivers. Tides in the main Chesapeake Bay near James Island represent the project area and are well predicted. Correlation in the main Bay near James is about 92% at Sharps Island Light, 96% at Long Beach, and 100% at Cove Point, and the peak tide is under-predicted by 0.07 to 0.08 ft.

Table 5-3: Current Velocity Calibration Statistics

	Time Series Statistics		
	Correlation	RMS Error (ft/sec)	RMS Error %
Main Cedar Point			
Cedar Point 1.1 nmi ENE	93%	0.28	15.7%
Cedar Point 2.9 nmi ENE	96%	0.34	19.7%
Main Cove Point			
Cove Point 1.1 nmi E	97%	0.18	7.9%
Cove Point 2.7 nmi E	96%	0.17	12.3%
Cove Point 3.9 nmi E	97%	0.22	10.5%
Main James Island			
Kenwood Beach 1.5mi NE	94%	0.16	19.1%
James Island 3.4 mi W	97%	0.15	12.3%
James Island 2.5 mi WNW	87%	0.16	10.5%
Main Sharps Island			
Plum Pt 2.1 mi N	96%	0.11	9.1%
Sharps Is Lt. 3.4 mi W	95%	0.15	12.8%
Sharps Is Lt. 2.1 W	92%	0.11	9.1%
Main Poplar Island			
Holland Pt 2 mi E	95%	0.15	18.4%
Poplar Is 2.2 mi WSW	96%	0.20	10.2%
Poplar Island E of S end	90%	0.54	19.7%
Main Thomas Point Shoal			
Thomas Pt Shoal Lt 1.8 mi SW	92%	0.10	8.1%
Thomas Pt Shoal Lt 0.5 m SE	95%	0.19	10.3%
Thomas Pt Shoal Lt 2 mi E	97%	0.11	6.6%
Main Sandy Point			
Sandy Point 0.8 nmi ESE	97%	0.43	13.8%
Sandy Point 2.3 nmi E	98%	0.17	7.8%
Main Baltimore			
Brewerton Channel Eastern Ext, Buoy 7	97%	0.24	18.7%
Swan Point 1.6 mi NW	98%	0.42	17.7%
Main Pooles Island			
Gunpowder River Entrance	94%	0.48	38.1%
Robins Point 0.7 mi ESE	89%	0.59	17.6%
Pooles Island 1.6 nmi E	98%	0.23	7.6%

Main Upper			
Howell Point 0.4 mi NNW	97%	0.49	15.8%
Turkey Point 1.2 nmi W	88%	0.33	19.4%
Patuxent River			
Hog Point 0.6 mi N	92%	0.09	6.9%
Choptank River			
Sharps Is Lt. 2.3 mi SE	97%	0.19	9.0%
Holland Pt 2 mi SSW	94%	0.09	12.9%
Chlora Pt 0.5 mi SSW	93%	0.16	11.8%
Cambridge Highway Bridge W of Swingspan	97%	0.28	22.6%
Poplar Pt S of	100%	0.08	3.1%
Eastern Bay			
Long Point 1 mi SE	88%	0.21	13.5%
Tilghman Point 1 mi N of	92%	0.12	10.9%
Parson's Island 0.7 NNE of	94%	0.08	15.1%
Kent Island Narrows Highway Bridge	95%	0.53	16.9%
Chester River			
Love Point 1.6 nmi E	95%	0.29	21.0%
Hail Point 0.7 nmi E	96%	0.17	11.0%
C & D Canal			
Arnold Point 0.4 mi W	87%	0.21	12.95%
C & D Canal, Chesapeake City Bridge	100%	0.01	0.13%

The above model calibration results show better than 90% correlation for most currents with the remaining better than 85%. Predicted current velocity percent error is typically less than 15% with the exception of some specific areas of the model which are closer to 20%. Near James Island, the correlation is between 87% to 97%. The factors affecting tidal elevation calibration, compounded with depth averaging in the model not reflecting the variation of currents with depth in the Bay, are the cause of the discrepancies between predicted and modeled currents.

5.3 SEDIMENTATION MODEL

Sedimentation model calibration typically requires historic sedimentation and erosion rates and detailed suspended sediment data. When these data are not available, the model can be used empirically to determine patterns and relative rates of sedimentation and erosion.

5.3.1 Non-Cohesive Sediment (Sand)

Studies performed by E2CR show fine surface sand in the vicinity of James Island. The non-cohesive sediment model was run using 0.1mm (.004 inch) sediment under no-wind conditions. Analysis of results shows negligible sand transport due to tidal currents. The non-cohesive sediment model was then run for each of 16 wind directions (E, ENE, NE, NNE, N, NNW, NW, WNW, W, WSW, SW, SSW, S, SSE, SE, and ESE) for wind speeds of 4-, 13-, and 16-mph corresponding to wind speed ranges from the wind rose shown in Figure 2-4.

Modeled non-cohesive sediment transport for existing conditions is negligible for 4- and 13-mph winds for all directions. Sixteen-mph winds, when taken cumulatively with lower wind speeds, account for nearly 90% of the yearly wind occurrences and cause significant sediment transport for winds from the NNW, SSE and WNW directions with negligible to moderate sediment transport for winds from other directions.

Model results for 16-mph winds from the NNW, SSE and WNW directions are shown in Figures 5-7, 5-8 and 5-9, respectively. Results are shown using a normalized unitless scale due to the empirical use of the sedimentation model and the lack of available data to verify model calibration.

Figure 5-7 shows areas of both erosion (green to blue) and accretion (yellow to orange) due to NNW winds. As shown in the figure, erosion generally occurs in the shallow waters around James Island, along the eastern shore of Taylors Island to the south, and within the Little Choptank River. Areas of accretion occur in the adjacent deeper areas west of James Island and Taylors Island, and within the Little Choptank River. To the north of James Island, erosion is observed in the shallows around Sharps Island Light, with accretion in the deeper waters east of the light. Figure 5-8 shows increased erosion and accretion potential due to SSE winds, indicated by the more extensive blue areas and patches of red. Similar to the NNW winds, erosion occurs in the shallow waters with accretion in the adjacent deeper waters. Impacts to the bottom sediment are west of James Island, with no effects in the Little Choptank River. Figure 5-9 shows erosion and accretion patterns due to WNW winds. As shown in this figure, erosion is not as pronounced, as the fetch distance from this direction is much shorter than the previous two directions. Erosion occurs mainly in the shallows close to James Island, along the Taylors Island shore, near Ragged Island in the Little Choptank River, and off Cook Point in Trippe Bay. Accretion again occurs in the deeper areas adjacent to the eroded shallow waters regions.

5.3.2 Cohesive Sediment (Clay and Silt)

Detailed cohesive sediment data, including suspended sediment concentrations, sedimentation and erosion rates, and spatial maps of specific surface sediment properties are not available for the project area. Since these data are unavailable, the sedimentation model was used empirically by assigning multiple thin layers of cohesive material with increasing cohesion and density over the entire domain. The layers erode and accrete in response to tidal current forcing and reach a dynamic equilibrium, meaning zero net sediment transport over a full lunar tidal cycle.

The UCB-FEM sedimentation model was initialized with nine cohesive layers of uniform thickness throughout the model domain. Layer calibration parameters include critical shear stresses of deposition (τ_{cd}) and erosion (τ_{ce}), erosion rate constant (E), bulk density (ρ), and settling velocity (w_s). The critical shear stress for deposition was set constant to 0.07 N/m^2 and settling velocity was set to 0.4 mm/second and increases as a function of concentration (Winterwerp, 1999). Other model layer parameters are shown in Table 5-4.

Sensitivity analyses show that sediment model boundary conditions are sufficiently far from the project area and have minimal impact on sediment transport in the project vicinity. Sediment model boundary conditions were set equal to the background values in the Bay. The resulting set of initial layer thicknesses shows the complete erosion of the upper layers in areas of high shear stress and deposition in quiescent areas.

Table 5-4: Sediment Model Initial Bed Layering				
Layer Number	Thickness (inches)	Critical Shear Strength, τ_{ce} (N/m^2)	Erosion Rate Constant, E (g/m^2/sec)	Dry Density, ρ_{dry} (kg/m^2)
1	0.25	0.07	0.200	334
2	0.25	0.16	0.200	450
3	0.25	0.21	0.200	500
4	0.5	0.27	0.100	550
5	0.5	0.33	0.100	600
6	0.5	0.45	0.100	650
7	1.0	0.57	0.050	650
8	1.0	0.69	0.050	650
9	1.0	0.82	0.050	650

The cohesive sediment model was run for a 6-month simulation period at which point the model was operating in a dynamic equilibrium. Ensuing with-project simulations show negligible erosion and accretion due to tidal currents. The cohesive sediment model was then run for each of 16 wind directions for wind speeds of 4- and 13-mph corresponding to wind speed ranges from the wind rose shown in Figure 2-4.

Modeled cohesive sediment transport is negligible for 4-mph. Thirteen-mph winds cause significant sediment transport for winds from the NNW, SSE, and WNW as shown in Figures 5-10 through 5-12, respectively, with negligible to moderate sediment transport for winds from other directions. Results are shown using a normalized unitless scale due to the empirical use of the sedimentation model and the lack of available data to verify model calibration. In general, for cohesive sediments the areas of erosion and accretion are larger than for non-cohesive sediment, as properties of cohesive sediment (shape, plasticitiy, electric charge) cause the particles to remain in suspension for relatively long periods of time before they settle out.

Figure 5-10 shows erosion due to NNW winds in the shallow areas west of James Island and Taylors Island, in the shallow regions of the Little Choptank River and Trippe Bay, and at Sharps Island Light. Accretion occurs southeast of James Island due to its sheltering effect from the NNW. Accretion also occurs in the adjacent deeper waters, but extends over a greater distance across the Bay to the Western Shore, south past Cove Point and north to the Choptank River.

Figure 5-11 presents results from SSE winds, and shows a greater area of erosion west of James Island and south along Taylors Island extending to Barren Island and Hooper Island. Erosion is also greater around Sharps Island Light. Accretion is not as wide spread as with NNW winds, but has higher potential in the central deep waters of the Bay. Increased accretion potential exists in the Little Choptank River with winds from the SSE. Figure 5-12 shows model results for WNW winds. As shown in this figure, although erosion occurs along the entire shoreline that is exposed to this direction, the erosion potential is not as great as the previous two conditions. Accretion occurs in the deeper waters adjacent to the erosional areas within the Bay, the Little Choptank River, Trippe Bay, and the Choptank River.

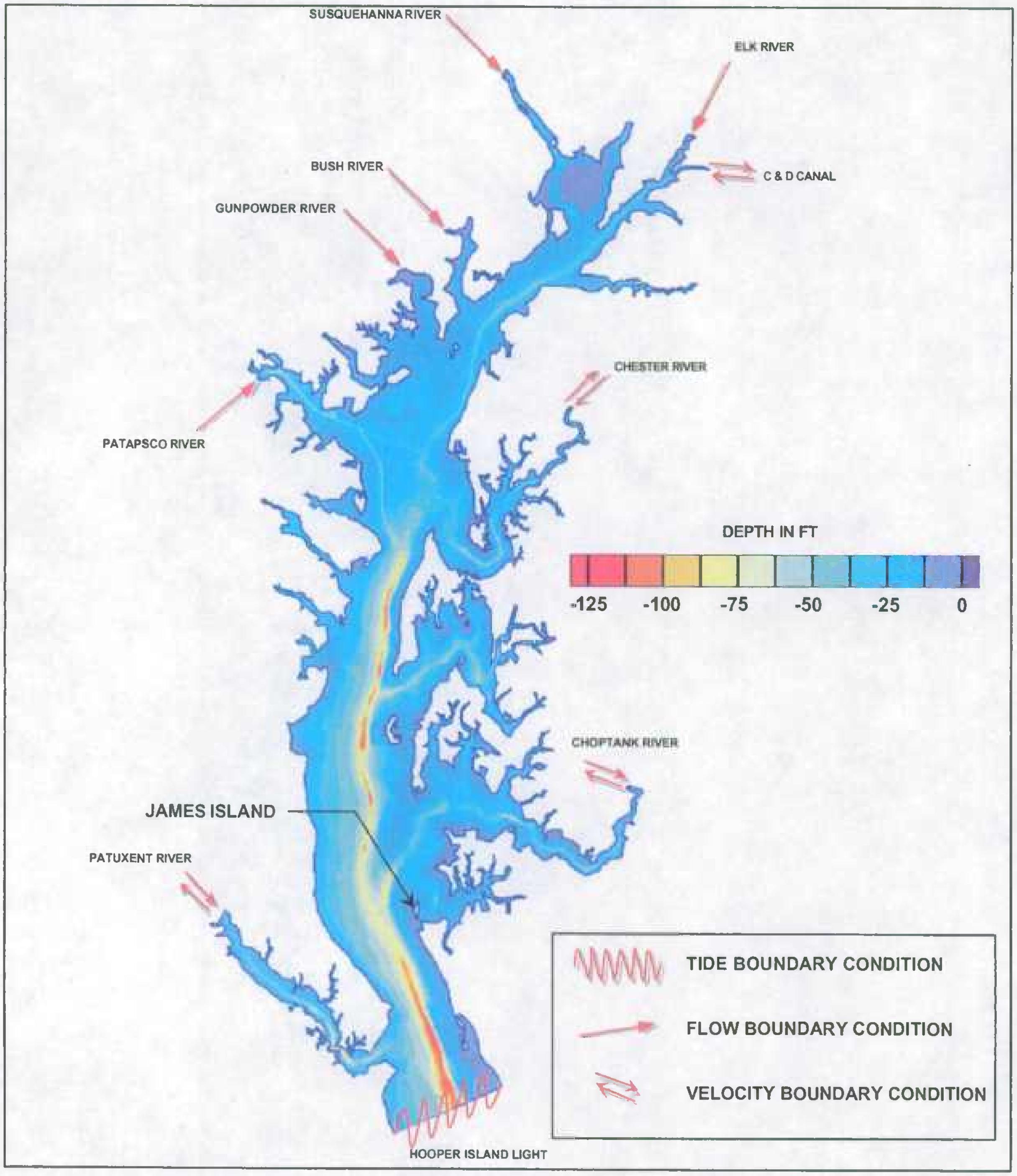


Figure 5-1: UCB-FEM Boundary Condition Locations

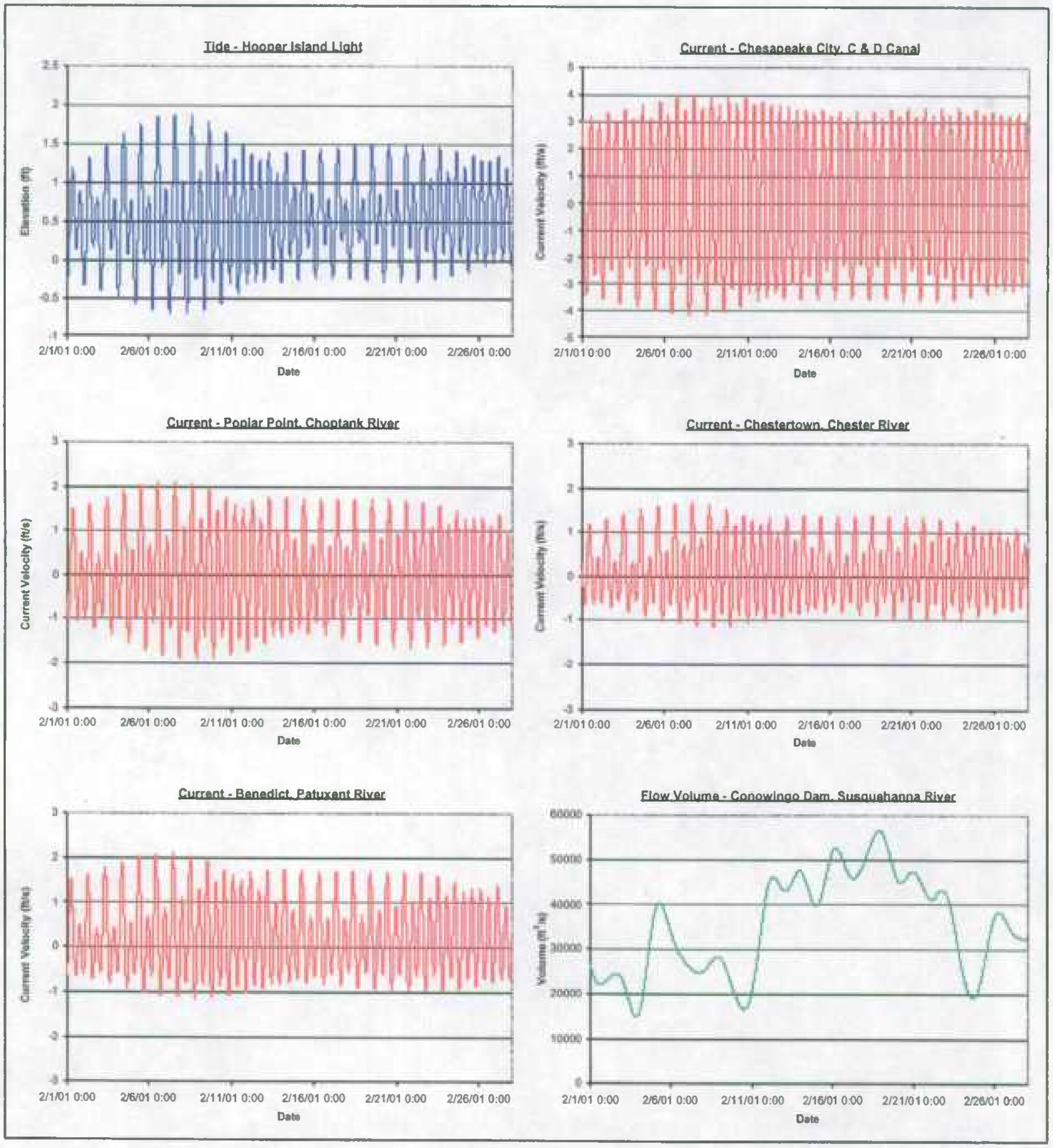


Figure 5-2: UCB-FEM Boundary Conditions

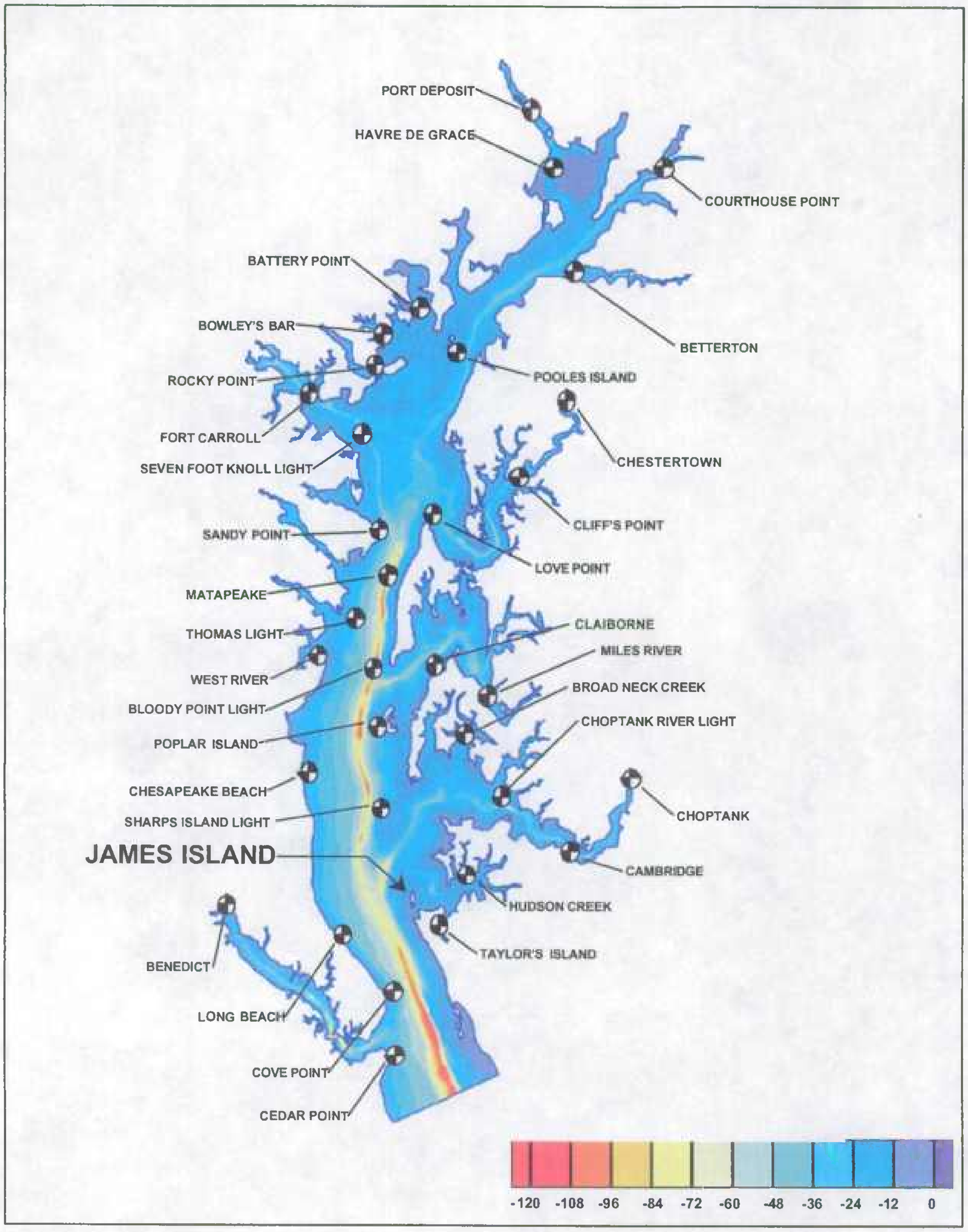


Figure 5-3: UCB-FEM Tidal Elevation Calibration Points

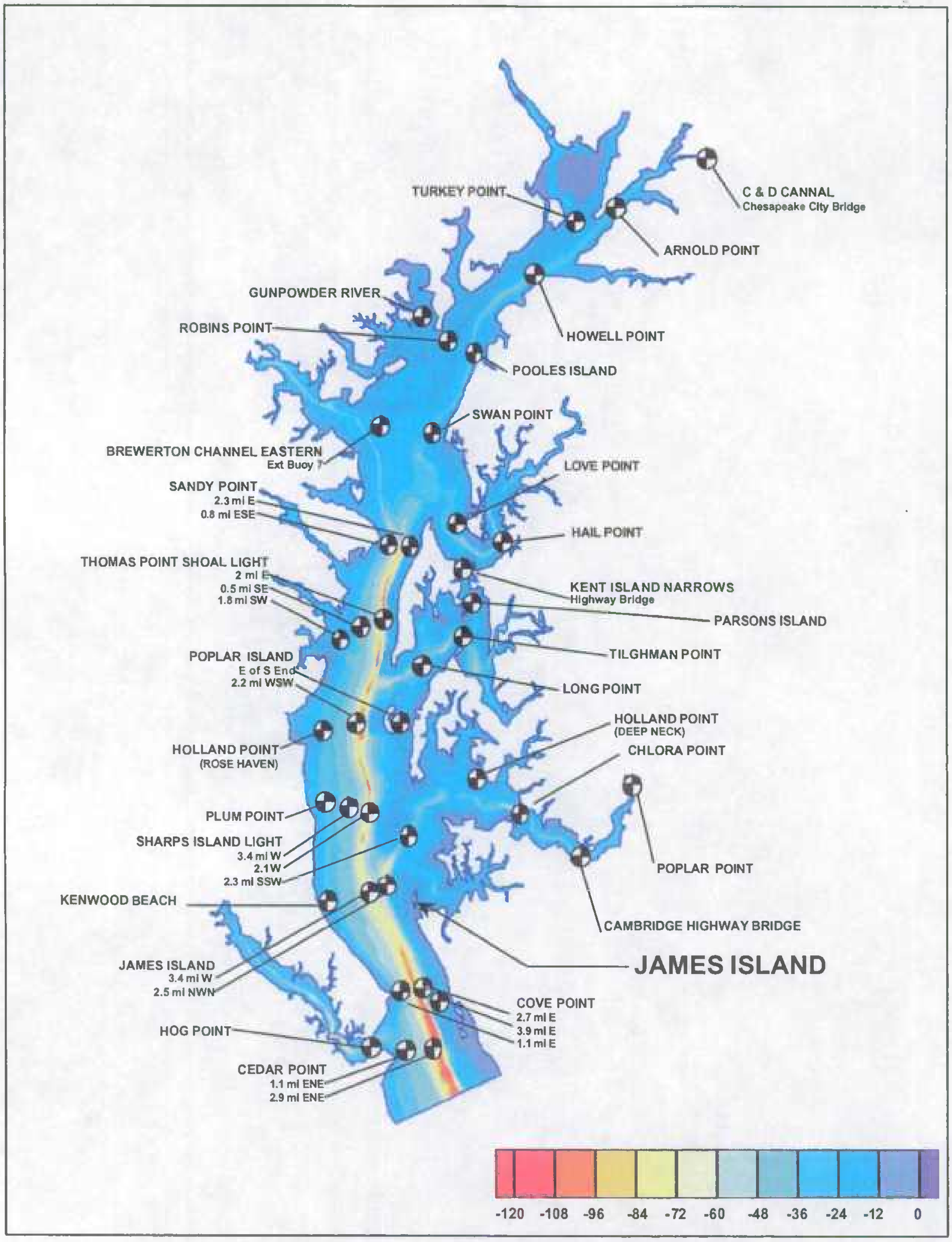


Figure 5-4: UCB-FEM Current Velocity Calibration Points

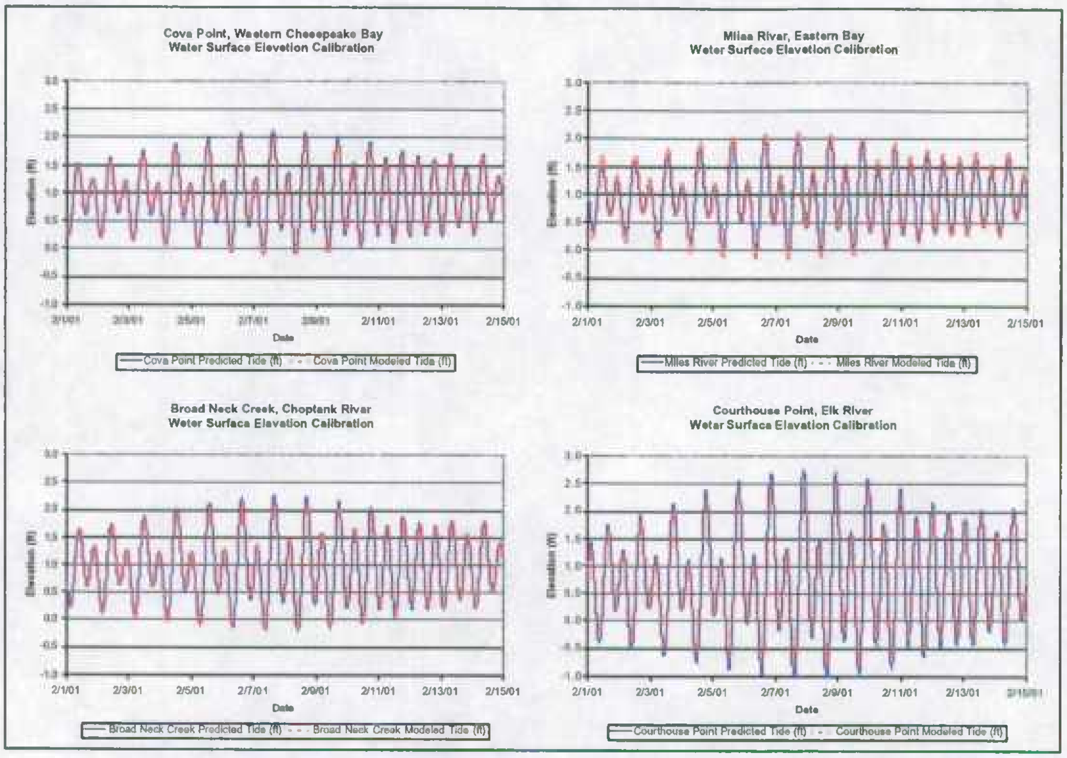


Figure 5-5: Tidal Elevation Calibration Results

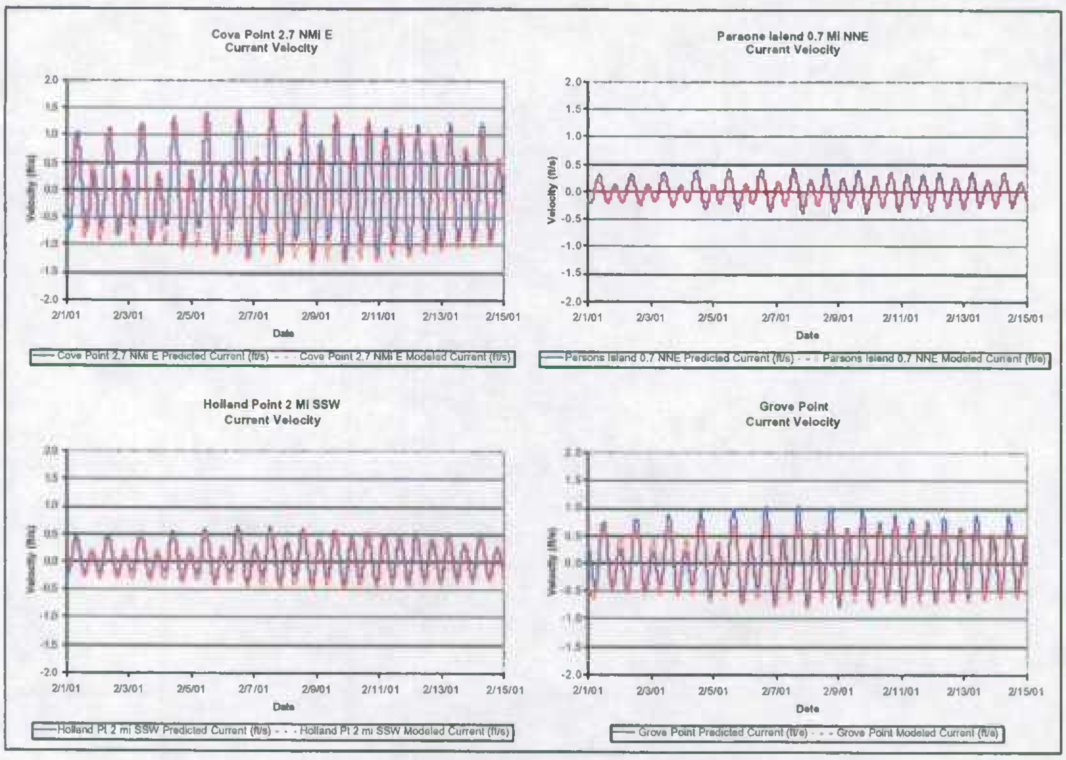


Figure 5-6: Current Velocity Calibration Results

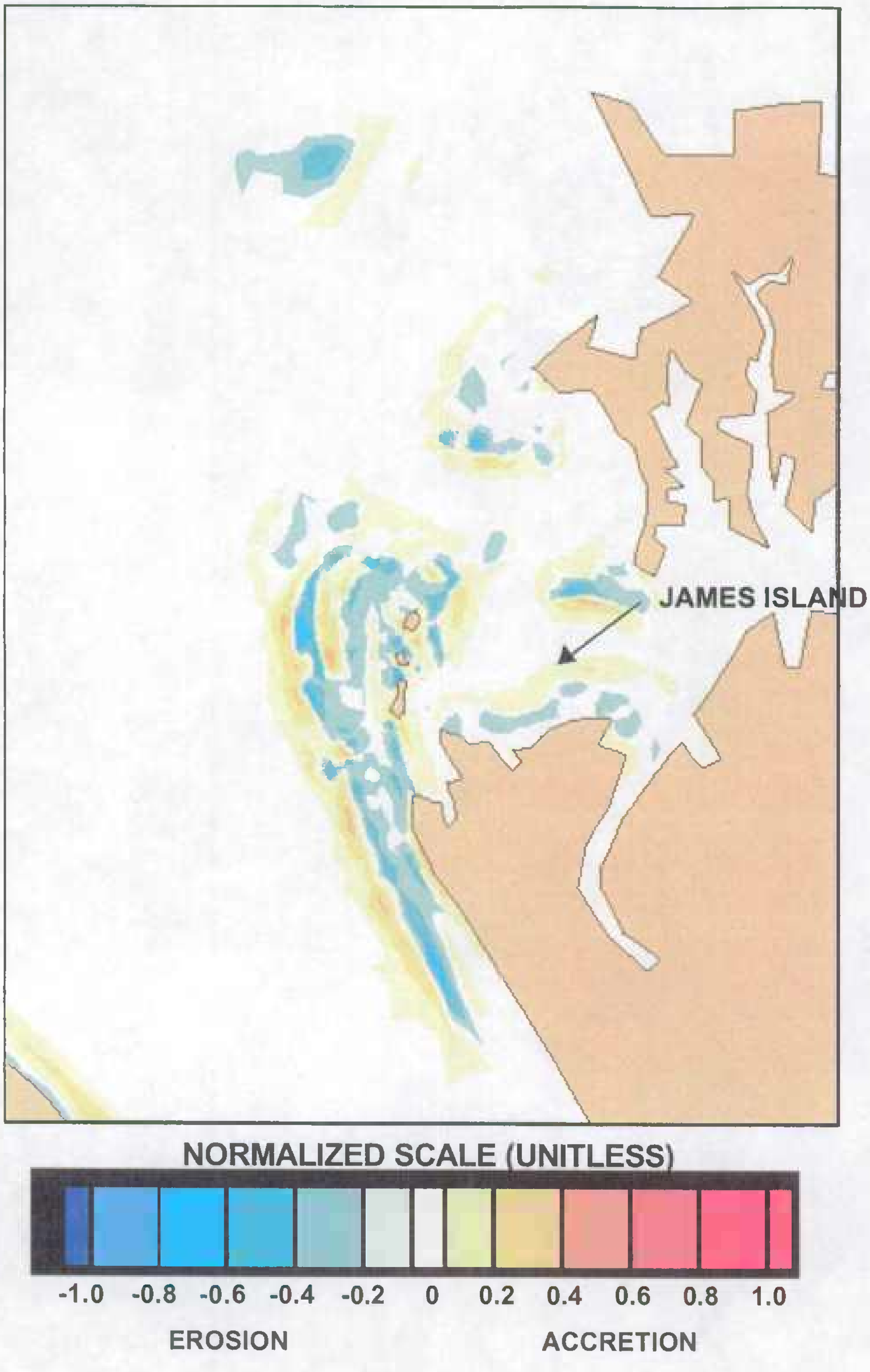


Figure 5-7: Non-Cohesive Sediment – NNW Wind 16 mph – Existing Conditions

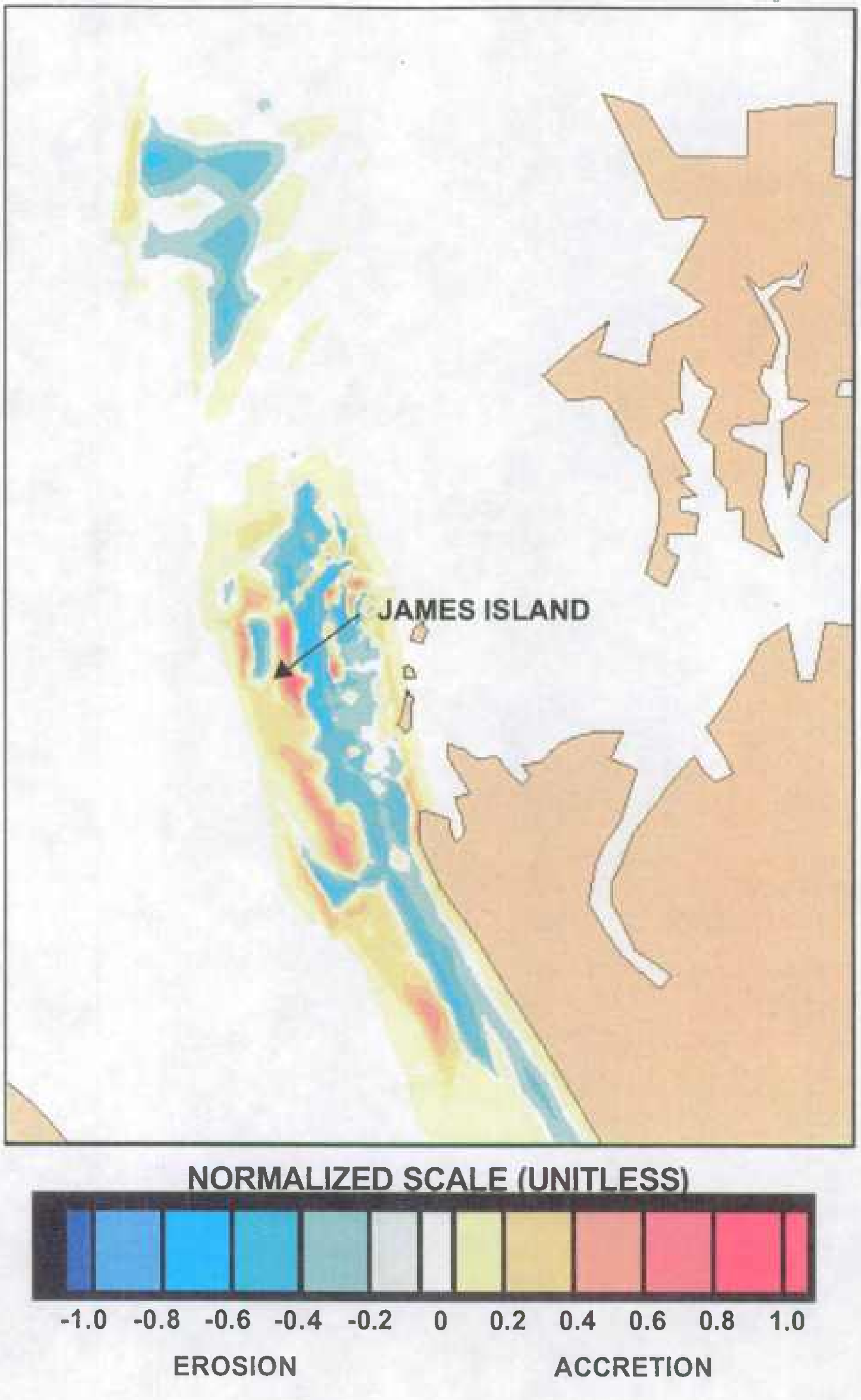


Figure 5-8: Non-Cohesive Sediment - SSE Wind 16 mph - Existing Conditions

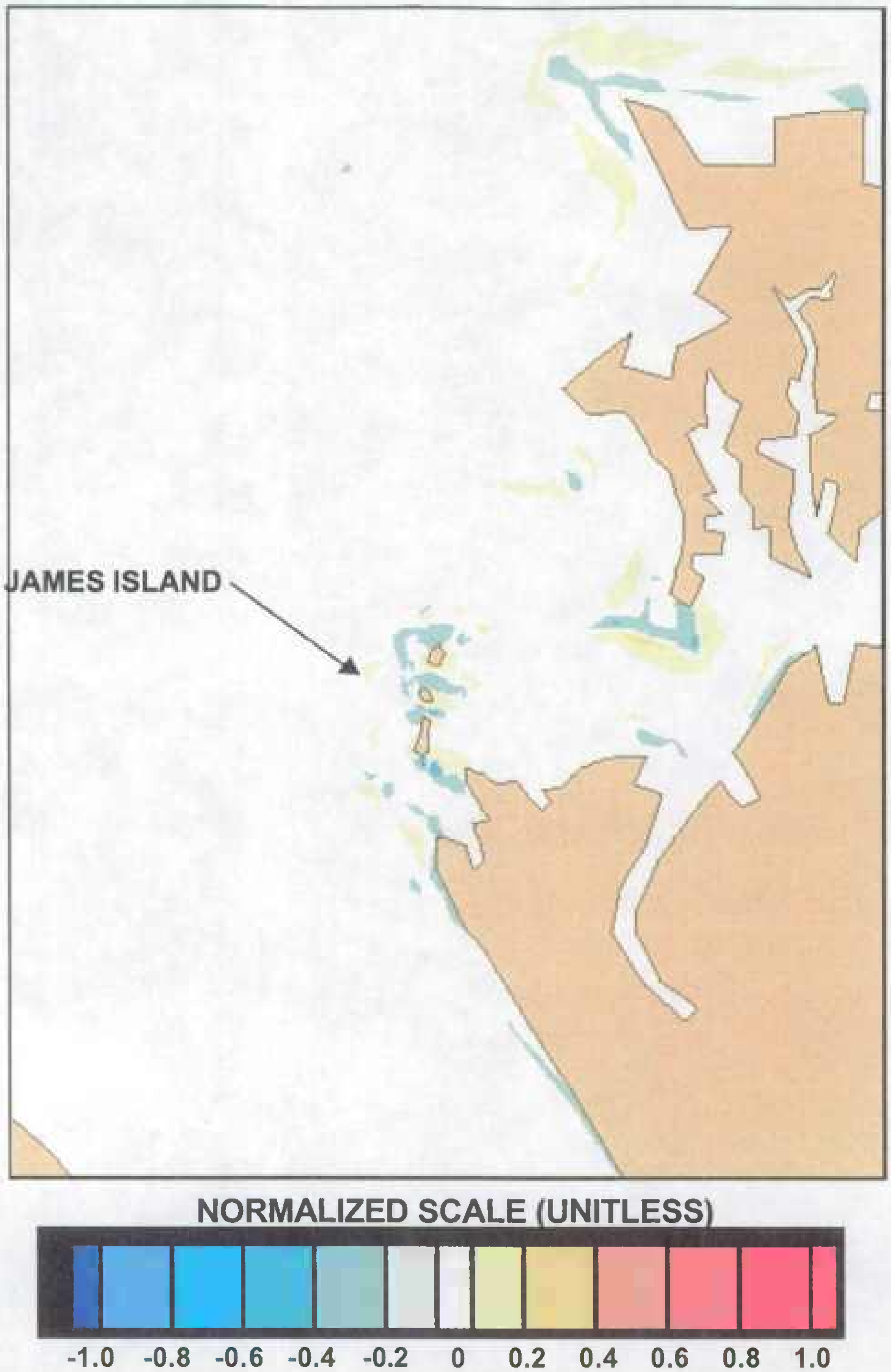


Figure 5-9: Non-Cohesive Sediment – WNW Wind 16 mph - Existing Conditions

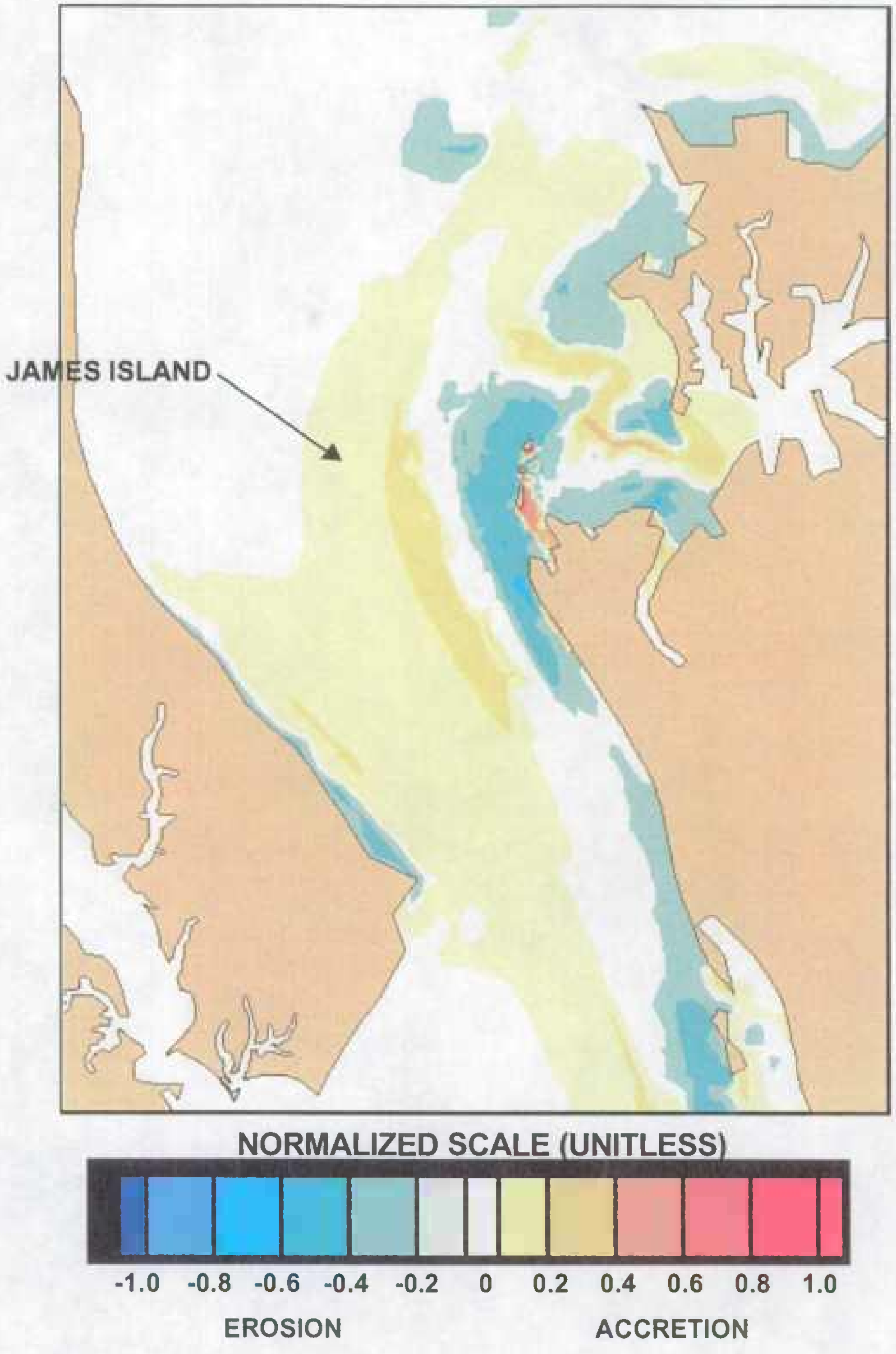


Figure 5-10: Cohesive Sediment – NNW Wind 13 mph - Existing Conditions

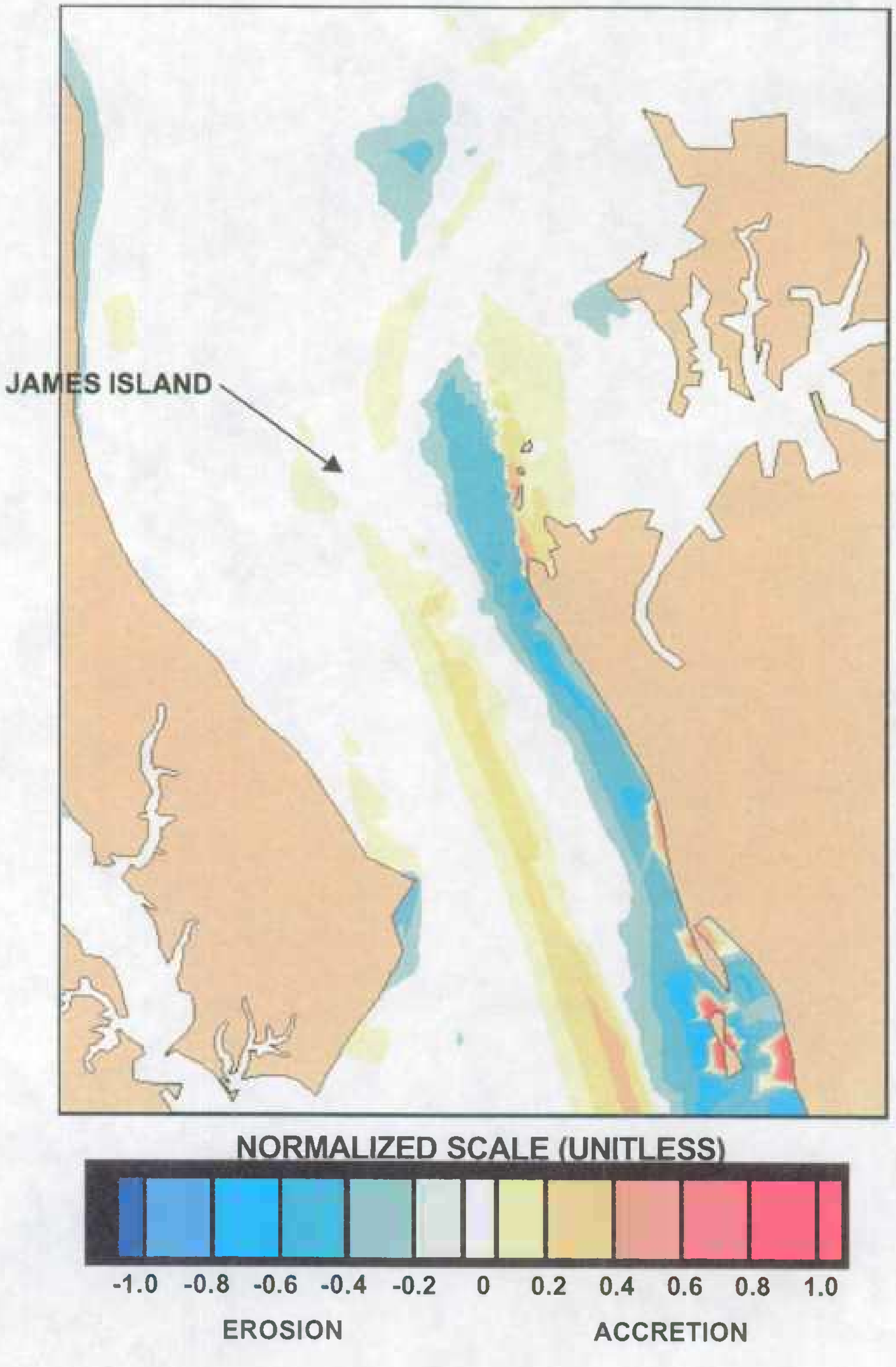


Figure 5-11: Cohesive Sediment – SSE Wind 13 mph - Existing Conditions

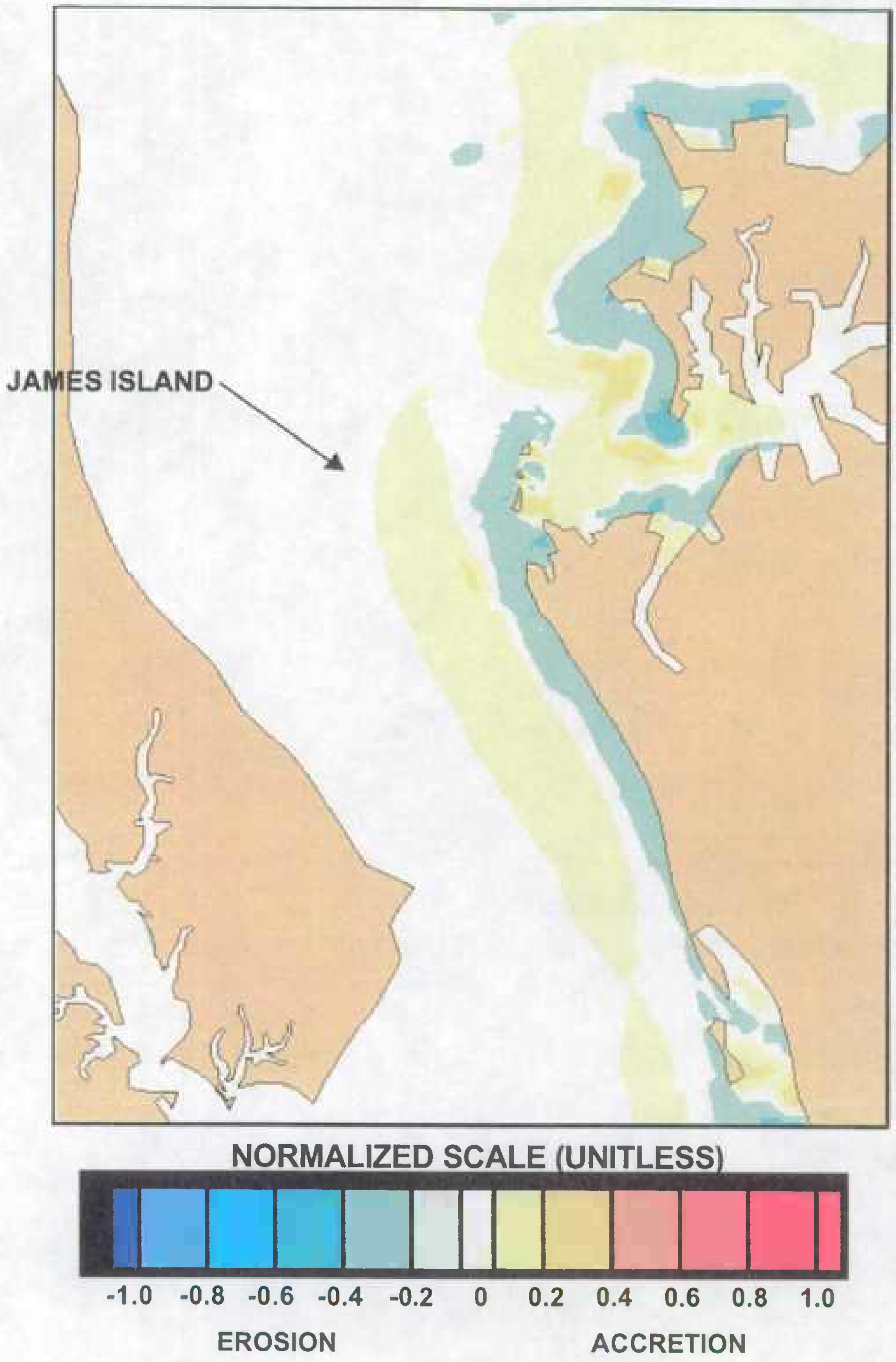


Figure 5-12: Cohesive Sediment – WNW Wind 13 mph - Existing Conditions

6. HYDRODYNAMIC MODELING RESULTS

6.1 GENERAL

Evaluation of the potential hydrodynamic impacts of the construction of the project at James Island has been conducted using the UCB-FEM model. The UCB-FEM model is used to assess potential impacts by applying identical hydrodynamic input boundary conditions to pre- and post- construction model bathymetry. Hydrodynamic results are then used as input into the sedimentation model which is also run using identical boundary conditions for pre- and post-construction conditions. The input conditions selected represent typical hydrodynamic conditions in the vicinity of James Island.

6.2 HABITAT ISLAND IMPACTS

Existing ebb and flood currents generally flow north and south in the main Bay west of James Island. In the gap between James Island and Taylors Island to the south, however, currents flow generally northeast on flood and southwest on ebb. The main flow into and out of the Little Choptank River generally follows the deeper natural channel around the north end of James Island. At peak flood tide, flow direction at this north end is towards the east, shifting southeast once past the mouth of the river. Ebb flow is reversed from flood; the magnitude of the flow velocities is about the same.

Results of the hydrodynamic simulations are compared numerically at locations north, east and south of the project site and visually for the entire project vicinity. The following sections describe the potential impacts of project construction on hydrodynamics.

6.2.1 Alignment 1

Figure 6-1 shows the location of three comparison stations in the vicinity of James Island and Alignment 1. Plots summarizing water surface elevation and current velocity results for Alignment 1 are presented in Figure 6-2 for these locations. Hydrodynamic model results indicate that projected water surface elevations would be unaffected by construction of the project. The results are expected as the area of the project is small compared to the Bay. Relatively small impacts, however, do occur to current velocities. Figures 6-3 and 6-4 visually show the predicted differences in peak current velocity in the project area due to construction of the project. Peak ebb and flood currents in the main Bay are not predicted to change should Alignment 1 be constructed. Following construction, predicted flow would be displaced northward and southward, and current velocity would increase both north and south of the project. Predicted current velocity decreases primarily around the existing James Island to the east where flow is blocked by the project. To a lesser extent, velocity decreases are predicted west of the project. Maximum velocity increases are projected at the southeast dike, between the project and the existing southern James Island, and where flow is trained along the northwest dike of the project as it enters the Little Choptank River.

Comparisons of peak current velocity hydrodynamic modeling results between existing conditions and Alignment 1 for the three locations are shown in Figure 6-2 and Table 6-1. Maximum predicted change around existing James Island is about 0.44 ft/sec; a lesser change is predicted in the Little Choptank River.

Table 6-1: Hydrodynamic Modeling Results – Alignment 1

	Existing Conditions		**Alignment 1**	
	Peak Flood Current (ft/sec)	***Peak Ebb Current (ft/sec)***	***Peak Flood Current (ft/sec)***	***Peak Ebb Current (ft/sec)***
North of Project	0.54	0.46	0.55	0.61
East of Project	0.50	**0.56**	**0.10**	**0.12**
South of Project	**0.32**	**0.32**	**0.74**	**0.72**

6.2.2 Alignment 2

Figure 6-5 shows the location of three comparison stations in the vicinity of James Island and Alignment 2. Plots summarizing predicted water surface elevation and current velocity results for Alignment 2 are presented in Figure 6-6. As with Alignment 1, hydrodynamic model results predict that water surface elevations would be unaffected by construction of the project, with relatively small impacts to current velocities. Figures 6-7 and 6-8 show the predicted differences in peak current velocity in the project area due to construction of the project. Peak ebb and flood currents in the main Bay are not predicted to change should Alignment 2 be constructed. Following construction, predicted flow would be displaced northward and southward, and current velocity would increase both north and south of the project. Predicted current velocity decreases primarily around the existing James Island to the east where flow is blocked by the project, but the area where velocities are reduced is larger for this alignment than Alignment 1 as the larger project area affords more protection. Smaller velocity decreases are predicted west of the project. Similar to Alignment 1, maximum velocity increases are predicted at the southeast dike between the project and the existing southern James Island, and where flow is trained along the northwest dike of the project as it enters the Little Choptank River.

Comparisons of peak current velocity hydrodynamic modeling results between existing conditions and Alignment 2 for the three locations are shown in Figure 6-6 and Table 6-2. Maximum predicted change around existing James Island is about 0.46 ft/sec; a lesser change is predicted in the Little Choptank River.

Table 6-2: Hydrodynamic Modeling Results – Alignment 2

	Existing Conditions		**Alignment 2**	
	Peak Flood Current (ft/sec)	***Peak Ebb Current (ft/sec)***	***Peak Flood Current (ft/sec)***	***Peak Ebb Current (ft/sec)***
North of Project	0.54	0.46	0.66	0.61
East of Project	0.50	**0.56**	**0.08**	**0.10**
South of Project	**0.49**	**0.47**	**0.74**	**0.75**

6.2.3 Alignment 3

Figure 6-9 shows the location of three comparison stations in the vicinity of James Island and Alignment 3, with plots summarizing predicted water surface elevations and current velocities presented in Figure 6-10. As before, results predict that water surface elevations would be unaffected by construction of the project and relatively small impacts occur to current velocities. Figures 6-11 and 6-12 visually show the predicted differences in peak current velocity in the project area due to construction of the project. Peak ebb and flood currents in the main Bay are not predicted to change should Alignment 3 be constructed. Following construction, flow is predicted to be displaced northward and southward, and current velocity is predicted to increase both north and south of the project. Current velocity decreases are predicted around the existing James Island to the east similarly to Alignment 2, and smaller velocity decreases are also predicted west of the project. Maximum velocity increases are predicted at the southeast dike between the project and the existing southern James Island, however, as this alignment extends further south, the increase in velocity is concentrated at the tip of the dike and extends to Taylors Island. Increase in velocity is also predicted where flow is trained along the northwest dike of the project as it enters the Little Choptank River.

Comparisons of peak current velocity hydrodynamic modeling results between existing conditions and Alignment 3 for the three locations are shown in Figure 6-10 and Table 6-3. Maximum predicted change around existing James Island is about 0.49 ft/sec; a lesser change is predicted in the Little Choptank River.

Table 6-3: Hydrodynamic Modeling Results – Alignment 3

	Existing Conditions		Alignment 3	
	Peak Flood Current (ft/sec)	*Peak Ebb Current (ft/sec)*	*Peak Flood Current (ft/sec)*	*Peak Ebb Current (ft/sec)*
North of Project	0.54	0.46	0.67	0.63
East of Project	0.50	**0.56**	**0.05**	**0.07**
South of Project	**0.53**	**0.52**	**0.81**	**0.82**

6.2.4 Alignment 4

Figure 6-13 shows the location of three comparison stations in the vicinity of James Island and Alignment 4, with plots summarizing predicted water surface elevation and current velocity results presented in Figure 6-14. As before, results predict that water surface elevations would be unaffected by construction of the project with relatively small impacts to current velocities. Figures 6-15 and 6-16 visually show the predicted differences in peak current velocity in the project area due to construction of the project. Peak ebb and flood currents in the main Bay are not predicted to change should Alignment 4 be constructed. Following construction, flow is predicted to be displaced northward and southward, and current velocity would increase both north and south of the project. Current velocity decreases are predicted primarily around the existing James Island to the east where flow is blocked by the project. This alignment provides the most protection to James Island and thus provides the greatest decrease in velocity. To a lesser extent, velocity decreases are predicted west of the project. This alignment also extends furthest south towards Taylors Island, and maximum velocity increases are predicted at the southeast dike between the project and Taylors Island. This predicted increase in velocity is greatest among all alignments. Velocity also is predicted to increase where flow is trained along the northwest dike of the project as it enters the Little Choptank River.

Comparisons of peak current velocity hydrodynamic modeling results between existing conditions and Alignment 4 for the three locations are shown in Figure 6-14 and Table 6-4. Maximum predicted change around existing James Island is about 0.50 ft/sec; a lesser change is predicted in the Little Choptank River.

Table 6-4: Hydrodynamic Modeling Results – Alignment 4

	Existing Conditions		Alignment 4	
	Peak Flood Current (ft/sec)	*Peak Ebb Current (ft/sec)*	*Peak Flood Current (ft/sec)*	*Peak Ebb Current (ft/sec)*
North of Project	0.54	0.46	0.69	0.65
East of Project	0.50	**0.56**	**0.05**	**0.06**
South of Project	**0.54**	**0.59**	**0.92**	**1.00**

6.2.5 Alignment 5

Figure 6-17 shows the location of three comparison stations in the vicinity of James Island and Alignment 5, with plots summarizing predicted water surface elevation and current velocity results presented in Figure 6-18. As for all cases, results predict that water surface elevations would be unaffected by construction of the project and small impacts occur to current velocities. Figures 6-19 and 6-20 visually show the predicted differences in peak current velocity in the project area due to construction of the project. Peak ebb and flood currents in the main Bay are not predicted to change should Alignment 5 be constructed. Following construction, flow is predicted to be displaced northward and southward, and current velocity is predicted to increase both north and south of the project. Current velocity decreases are predicted primarily around the existing James Island to the east where flow is blocked by the project; the reduction in velocity is similar to Alignments 2 and 3. To a lesser extent, velocity decreases are predicted west of the project. Maximum velocity increases are predcited at the southeast dike between the project and the existing southern James Island, similar to Alignment 2 as these both have southern boundaries about the same location. Velocity increases are also predicted where flow is trained along the northwest dike of the project as it enters the Little Choptank River.

Comparisons of peak current velocity hydrodynamic modeling results between existing conditions and Alignment 5 for the three locations are shown in Figure 6-18 and Table 6-5. Maximum predicted change around existing James Island is about 0.48 ft/sec; a lesser change is predicted in the Little Choptank River.

Table 6-5: Hydrodynamic Modeling Results – Alignment 5

	Existing Conditions		Alignment 5	
	Peak Flood Current (ft/sec)	*Peak Ebb Current (ft/sec)*	*Peak Flood Current (ft/sec)*	*Peak Ebb Current (ft/sec)*
North of Project	0.54	0.46	0.66	0.62
East of Project	0.50	**0.56**	**0.06**	**0.08**
South of Project	**0.50**	**0.52**	**0.84**	**0.92**

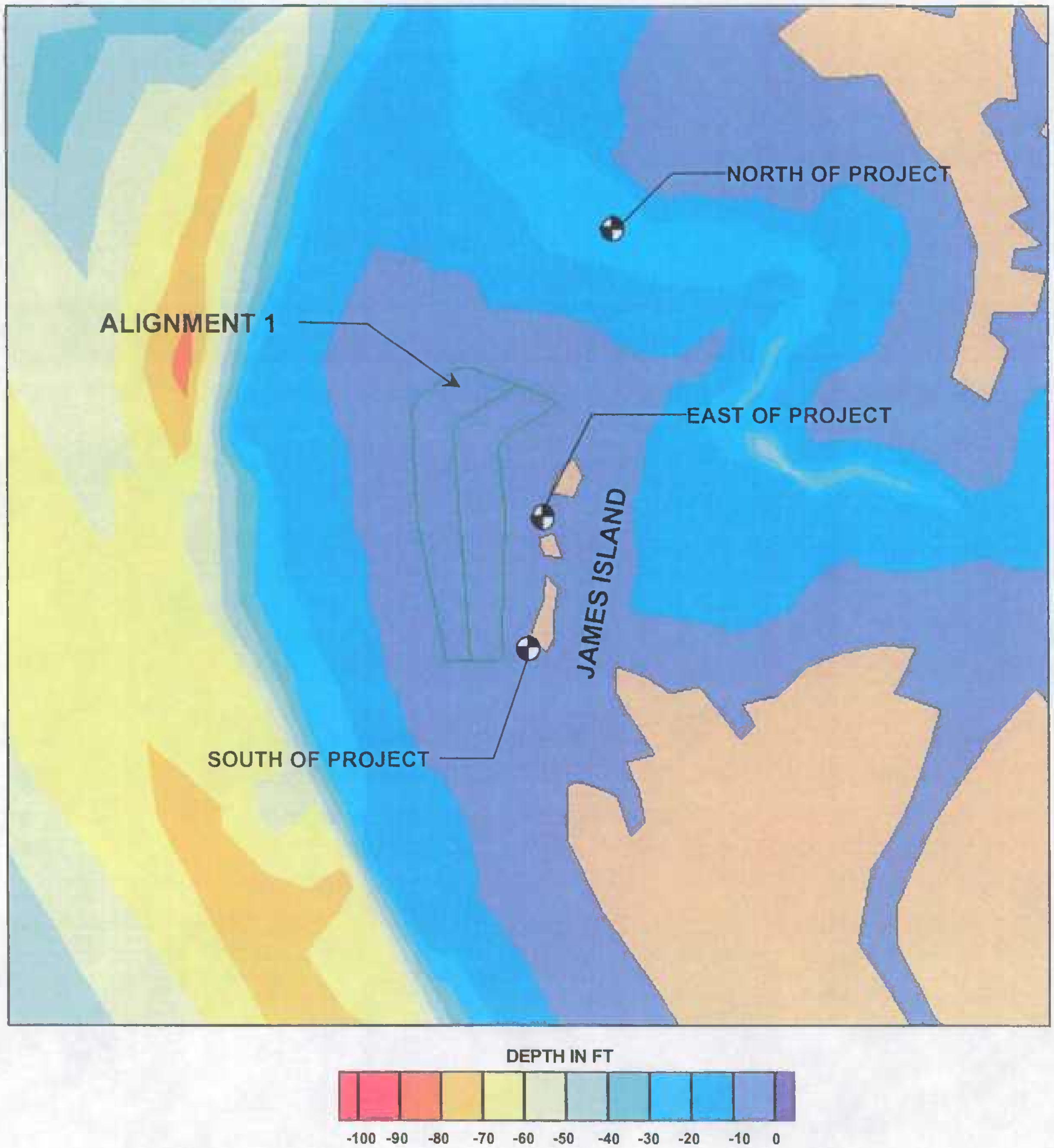


Figure 6-1: Results Comparison Locations for Alignment 1

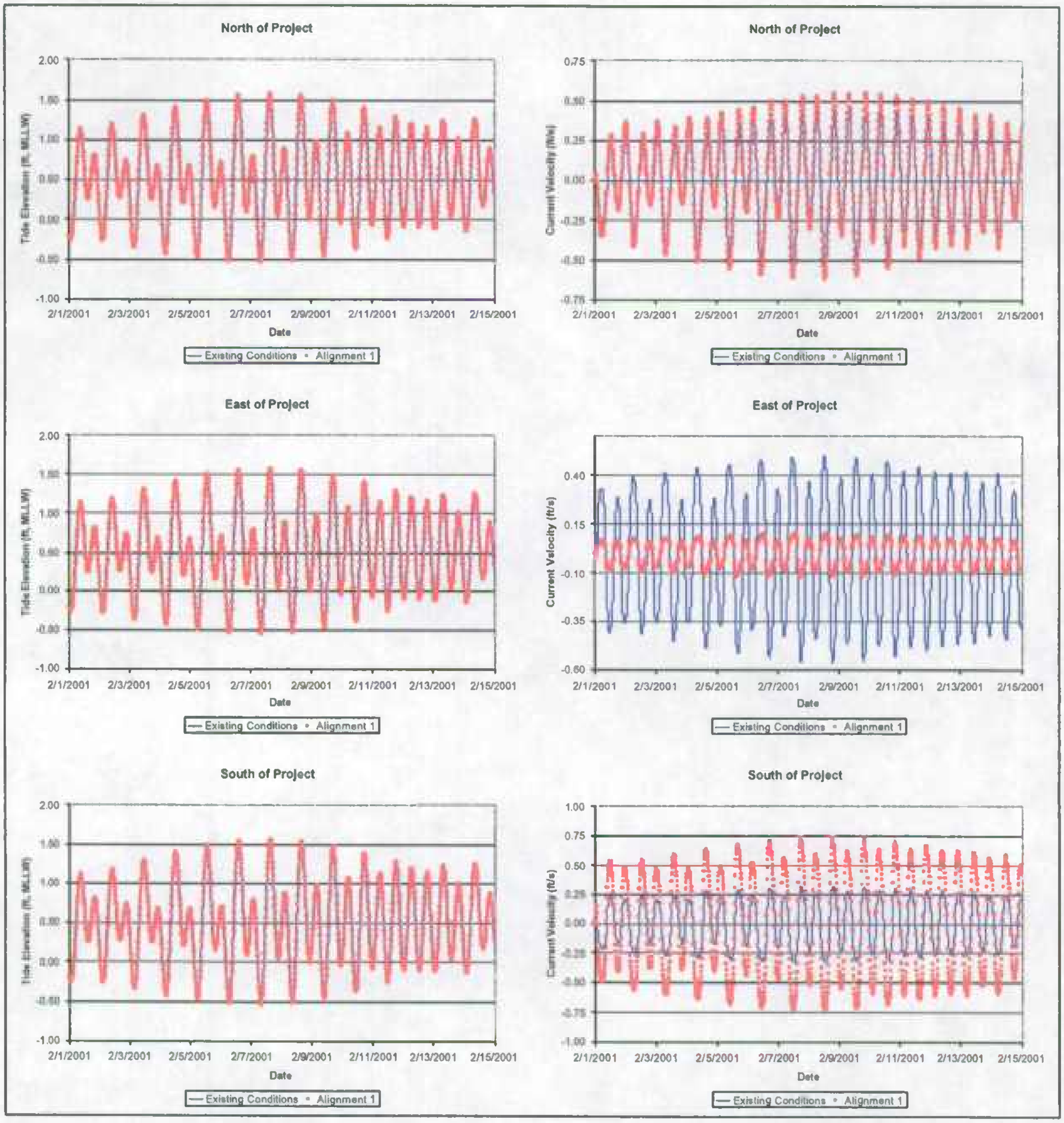


Figure 6-2: James Island Tidal Results Comparison for Alignment 1

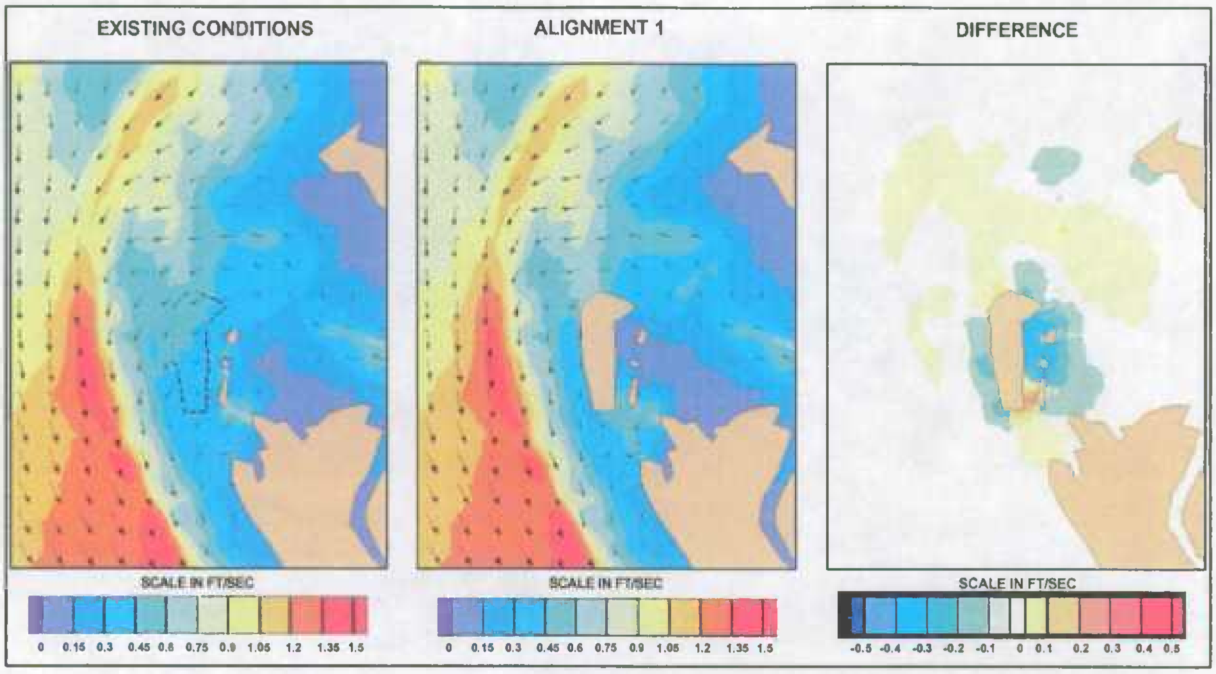


Figure 6-3: Peak Ebb Current Velocity – Alignment 1 vs. Existing Conditions

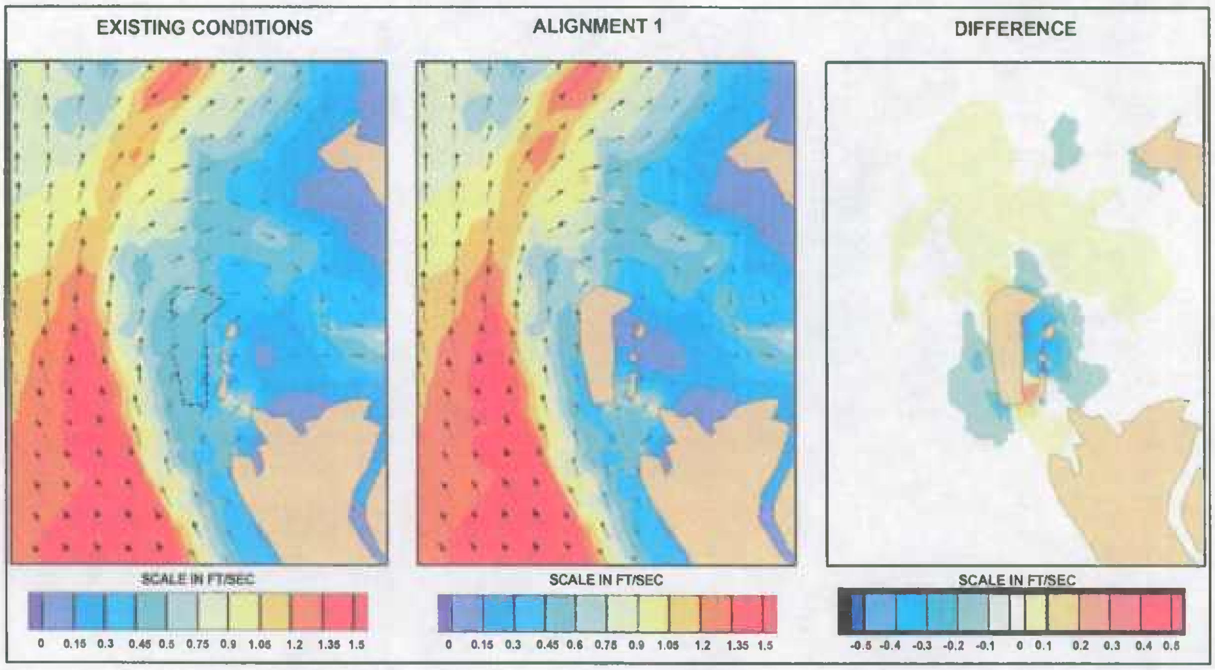


Figure 6-4: Peak Flood Current Velocity – Alignment 1 vs. Existing Conditions

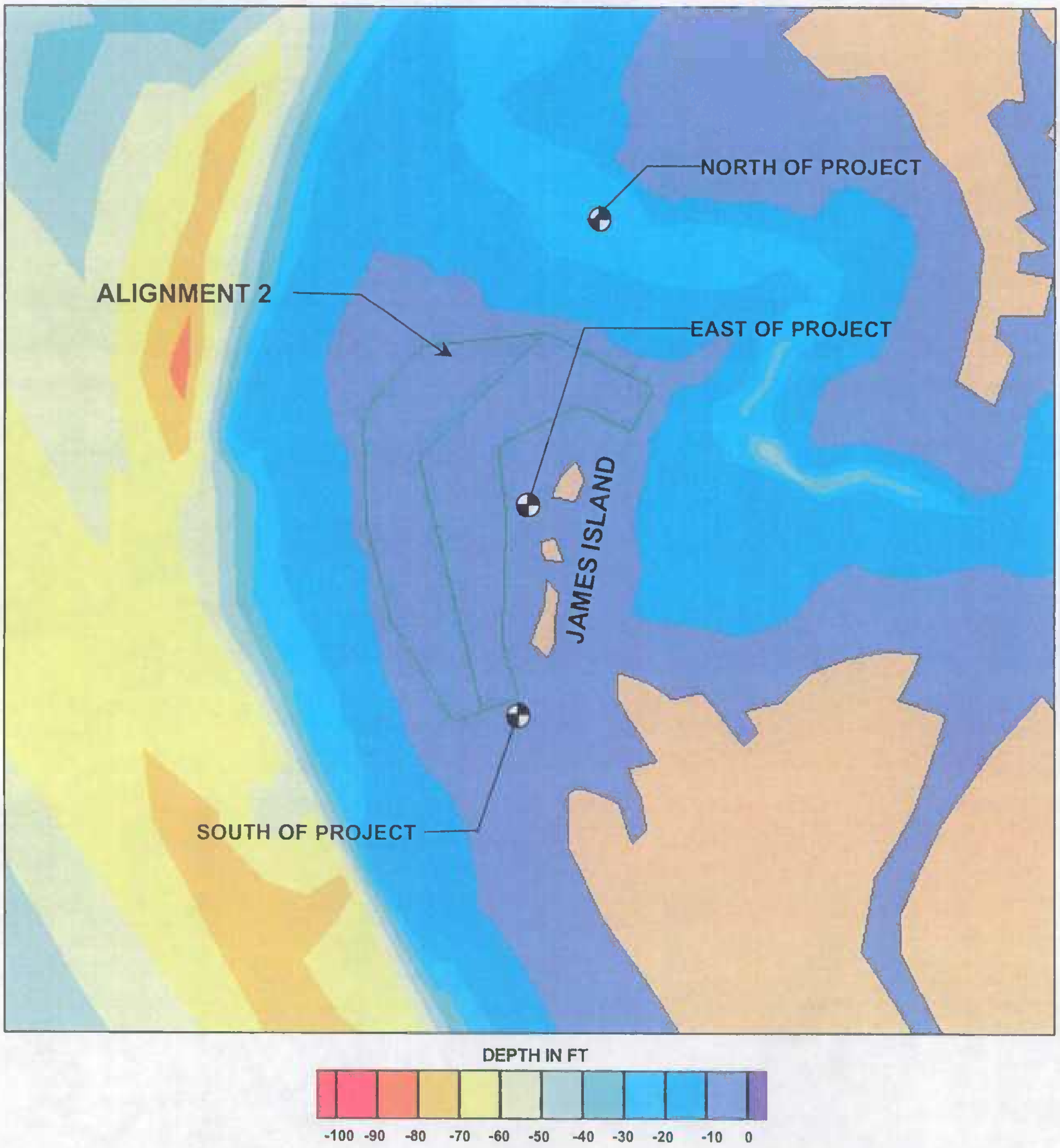


Figure 6-5: Results Comparison Locations for Alignment 2

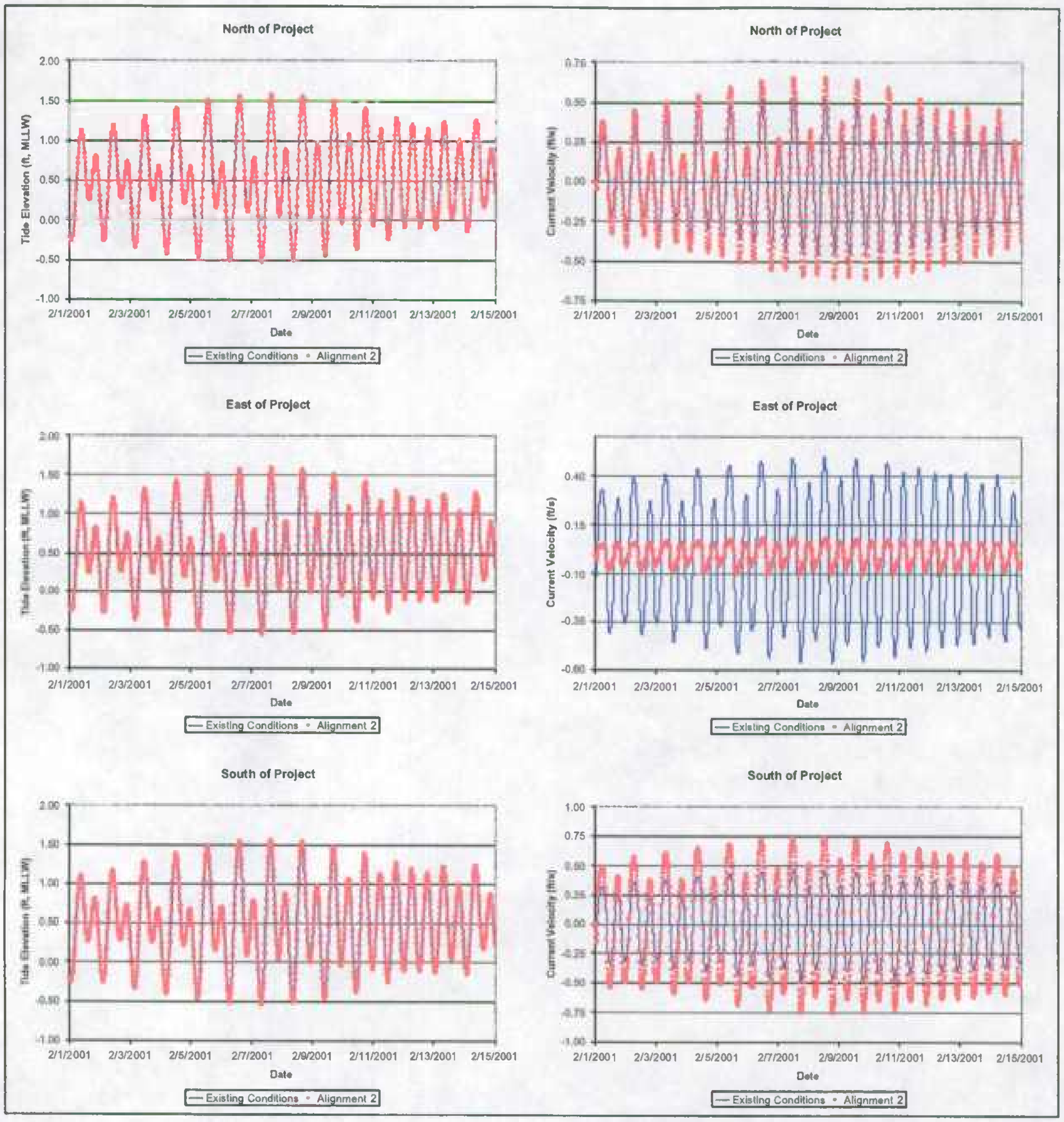


Figure 6-6: James Island Tidal Results Comparison for Alignment 2

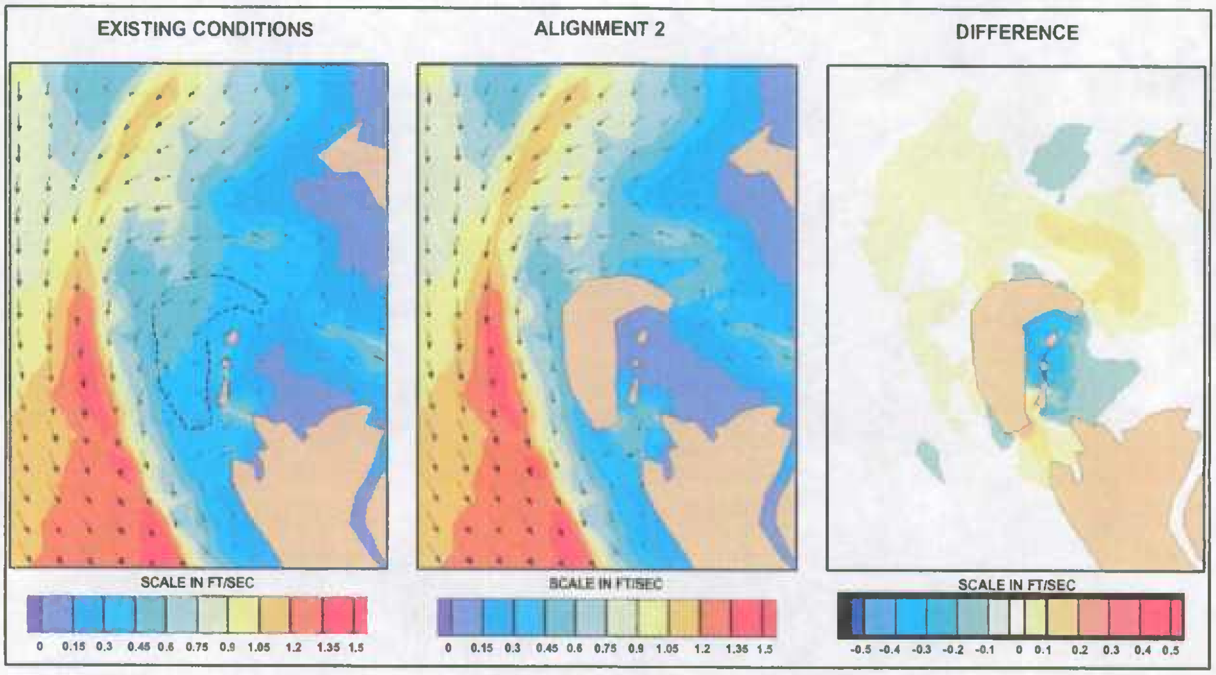


Figure 6-7: Peak Ebb Current Velocity – Alignment 2 vs. Existing Conditions

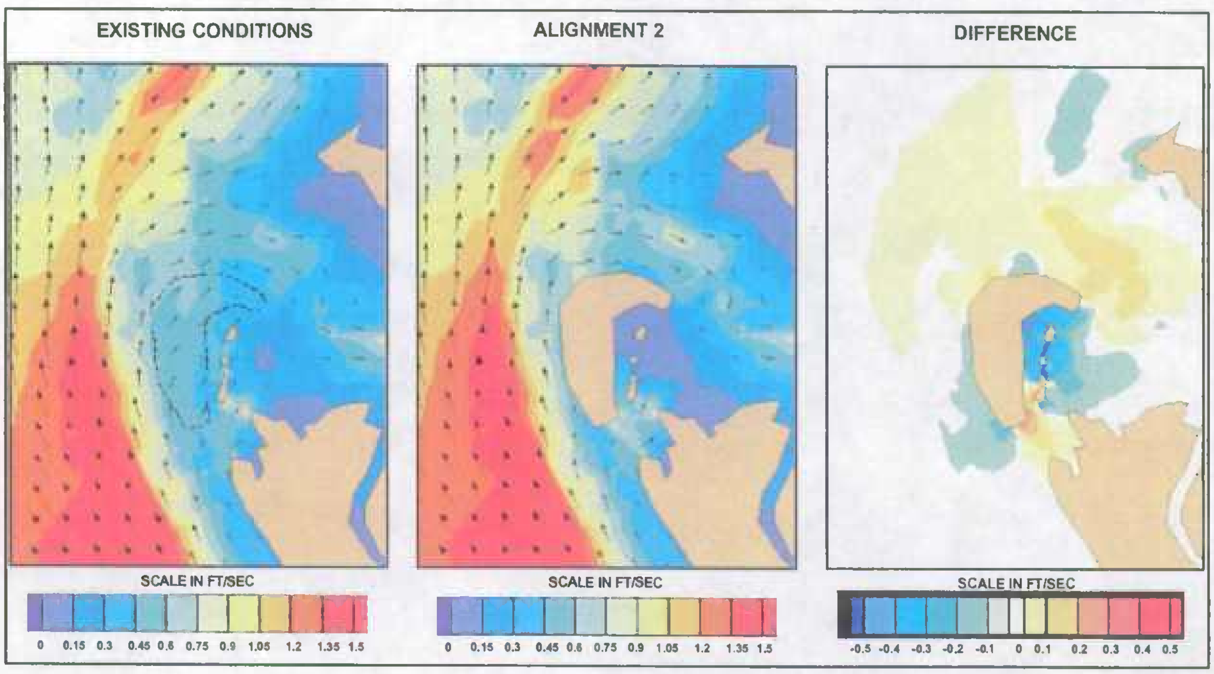


Figure 6-8: Peak Flood Current Velocity – Alignment 2 vs. Existing Conditions

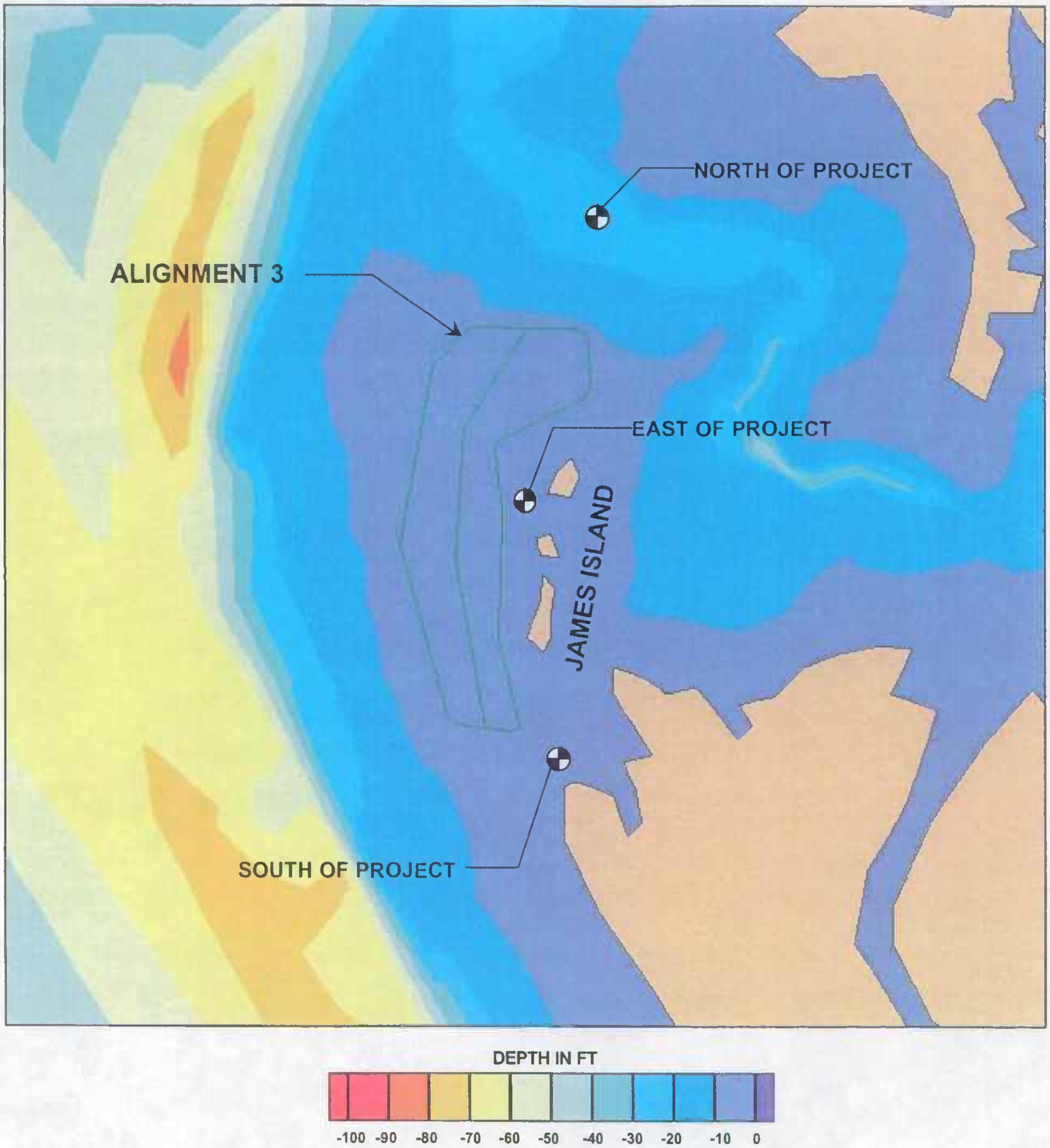


Figure 6-9: Results Comparison Locations for Alignment 3

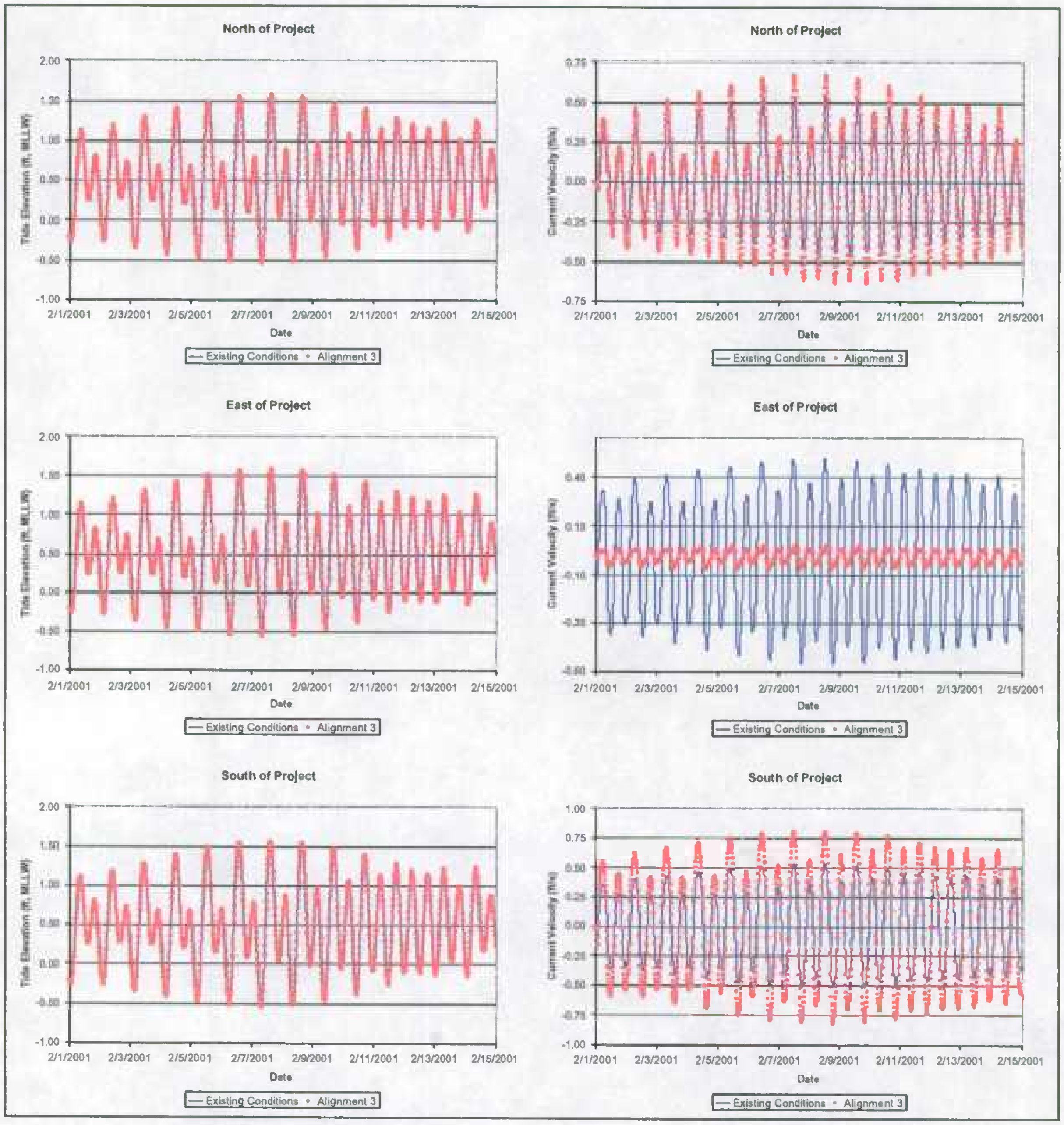


Figure 6-10: James Island Tidal Results Comparison for Alignment 3

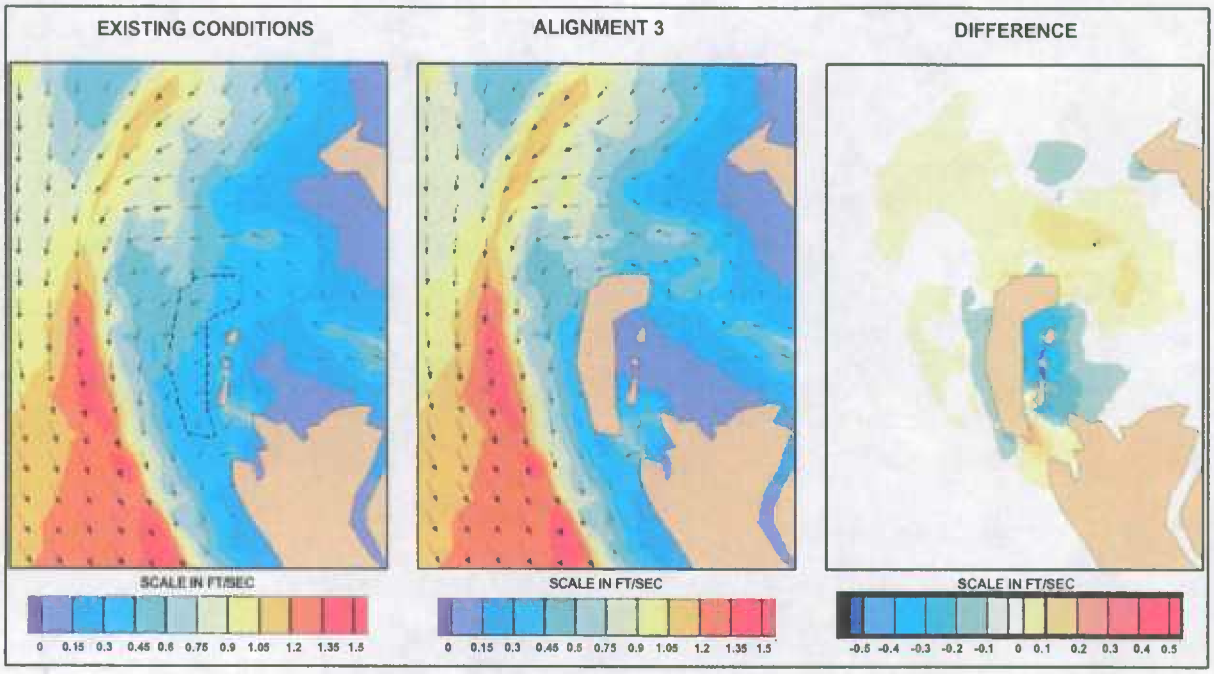


Figure 6-11: Peak Ebb Current Velocity – Alignment 3 vs. Existing Conditions

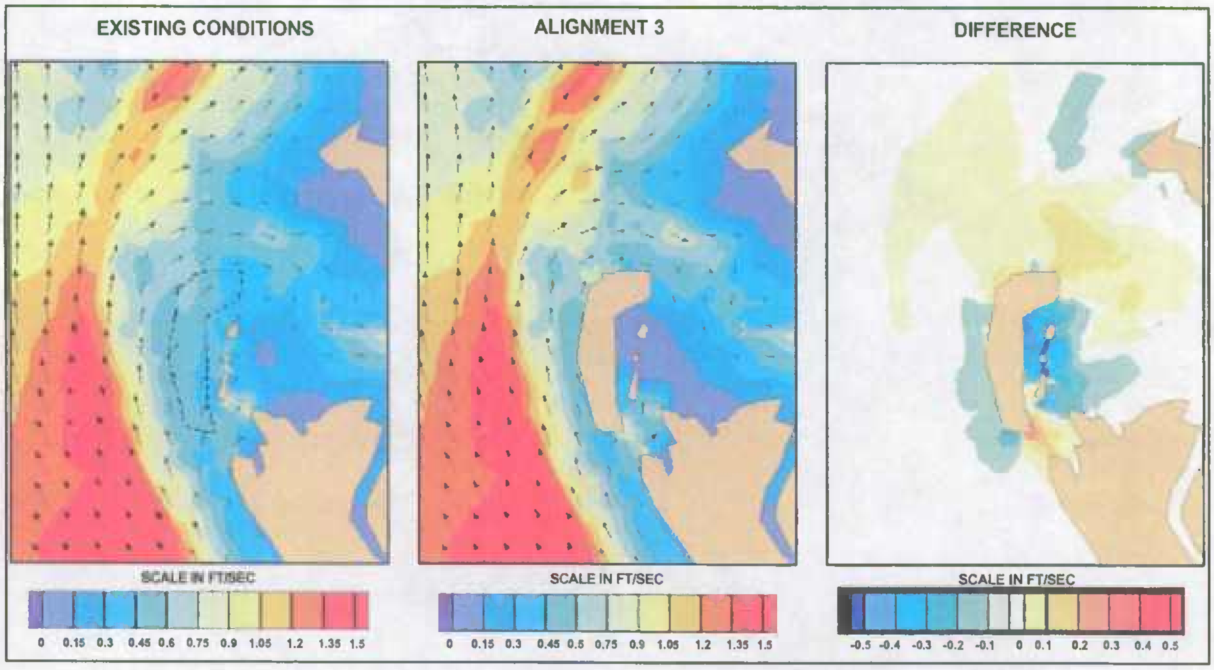


Figure 6-12: Peak Flood Current Velocity – Alignment 3 vs. Existing Conditions

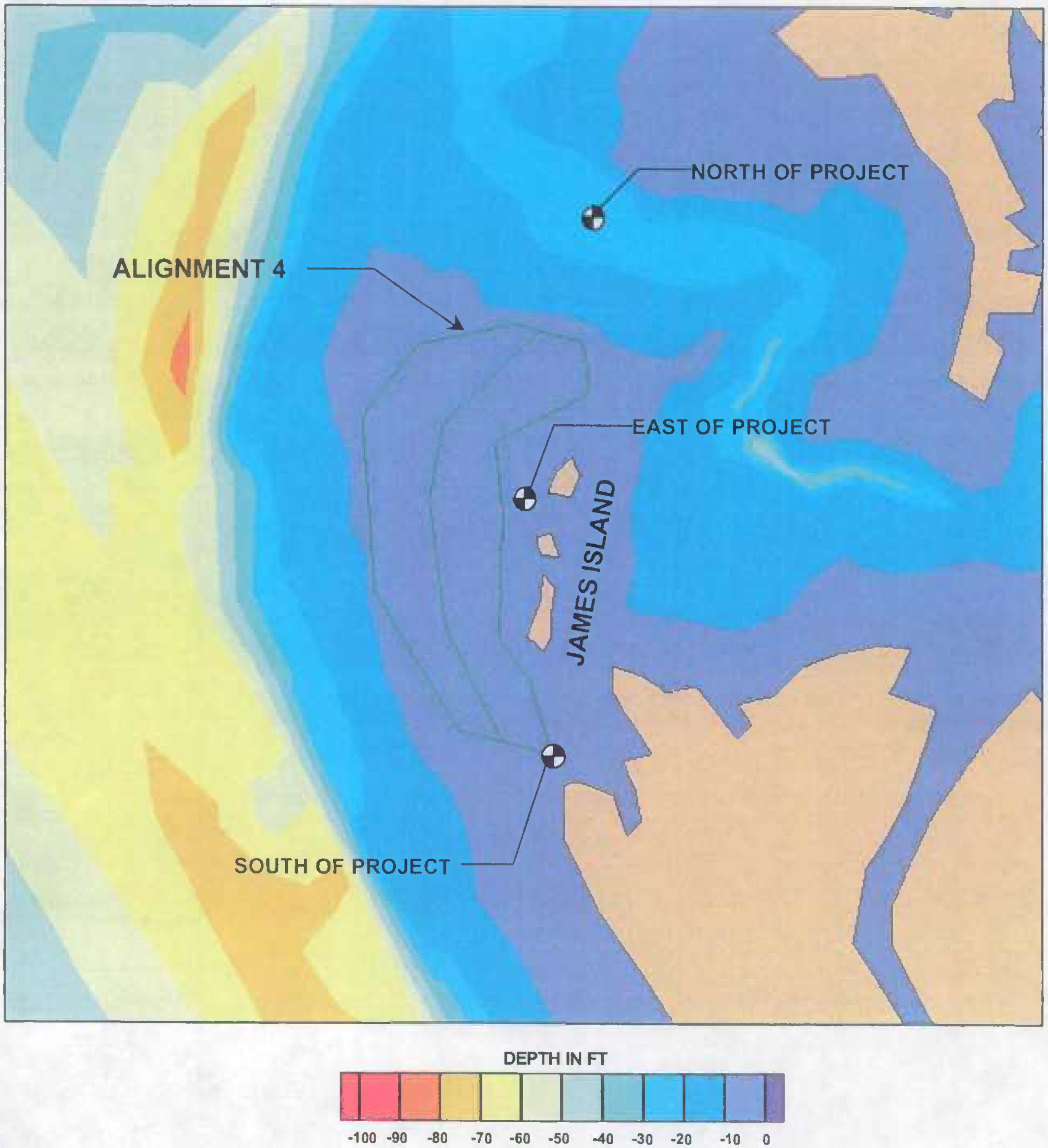


Figure 6-13: Results Comparison Locations for Alignment 4

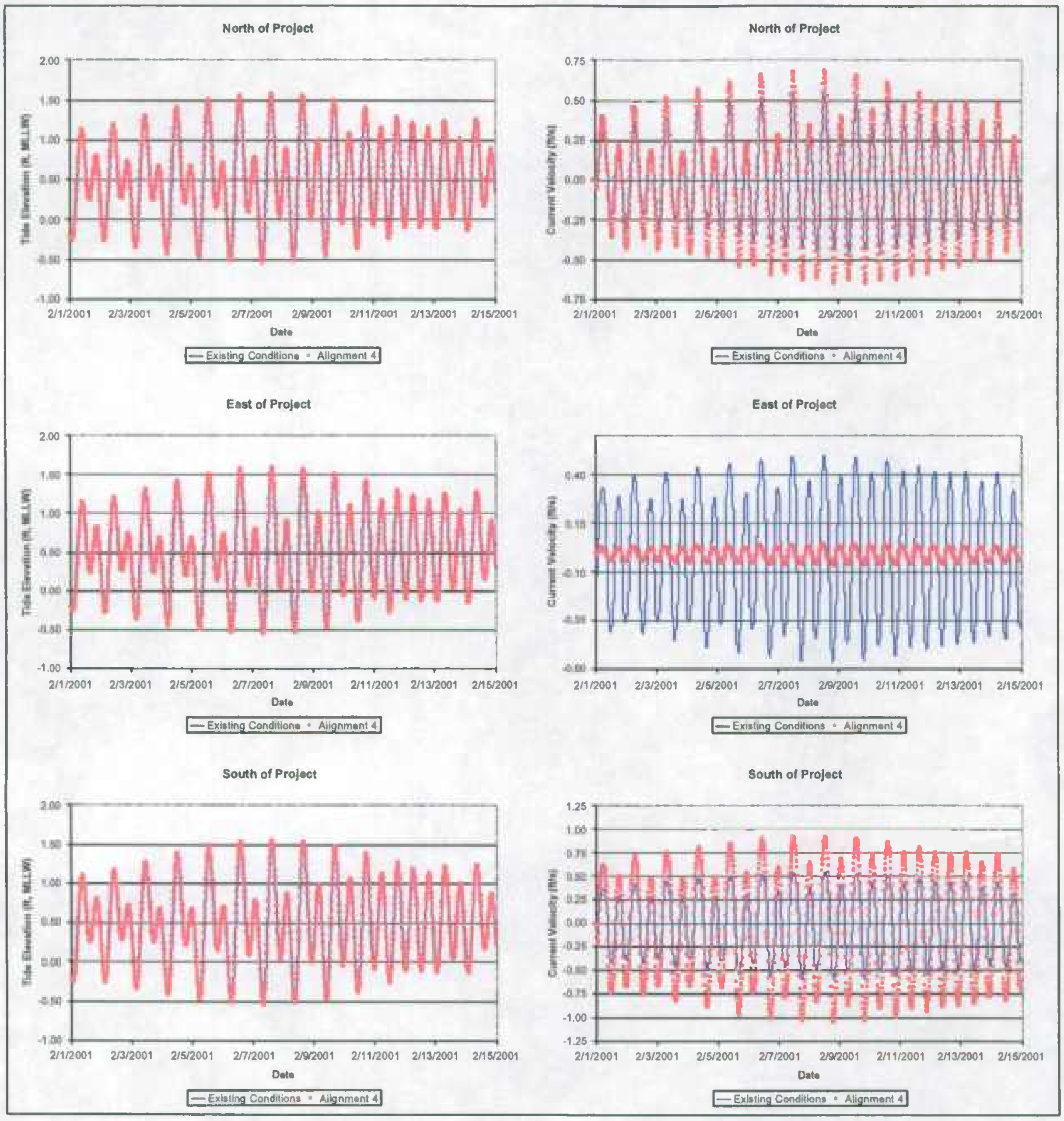


Figure 6-14: James Island Tidal Results Comparison for Alignment 4

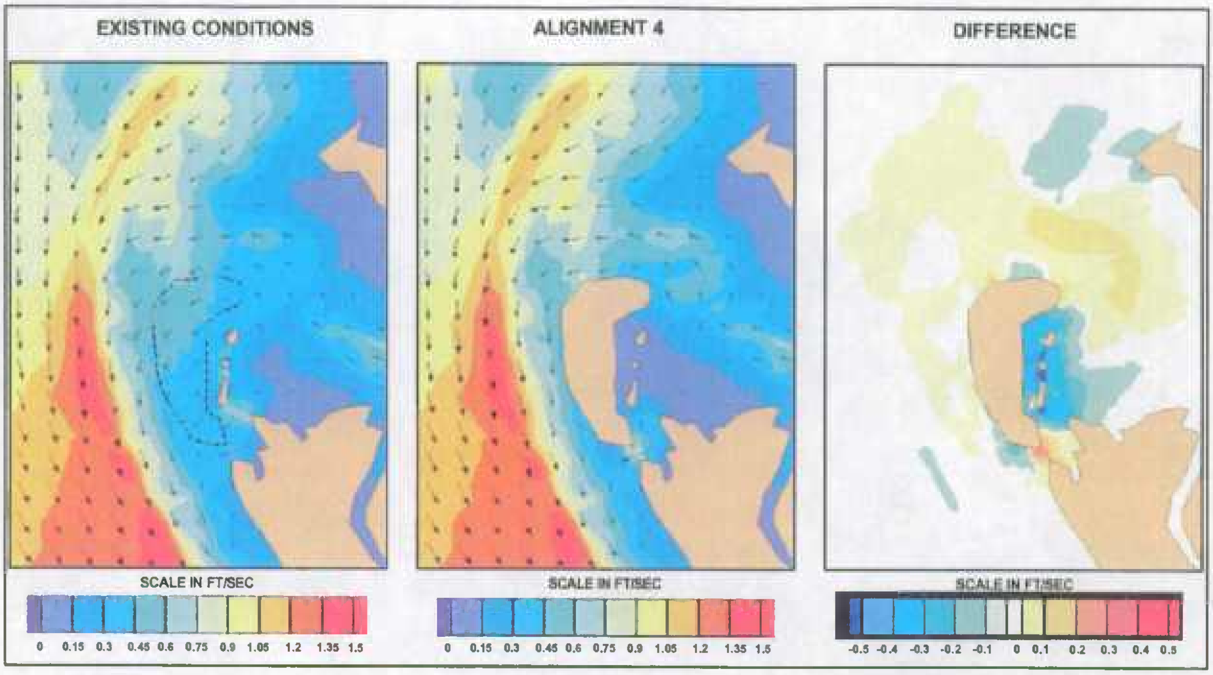


Figure 6-15: Peak Ebb Current Velocity – Alignment 4 vs. Existing Conditions

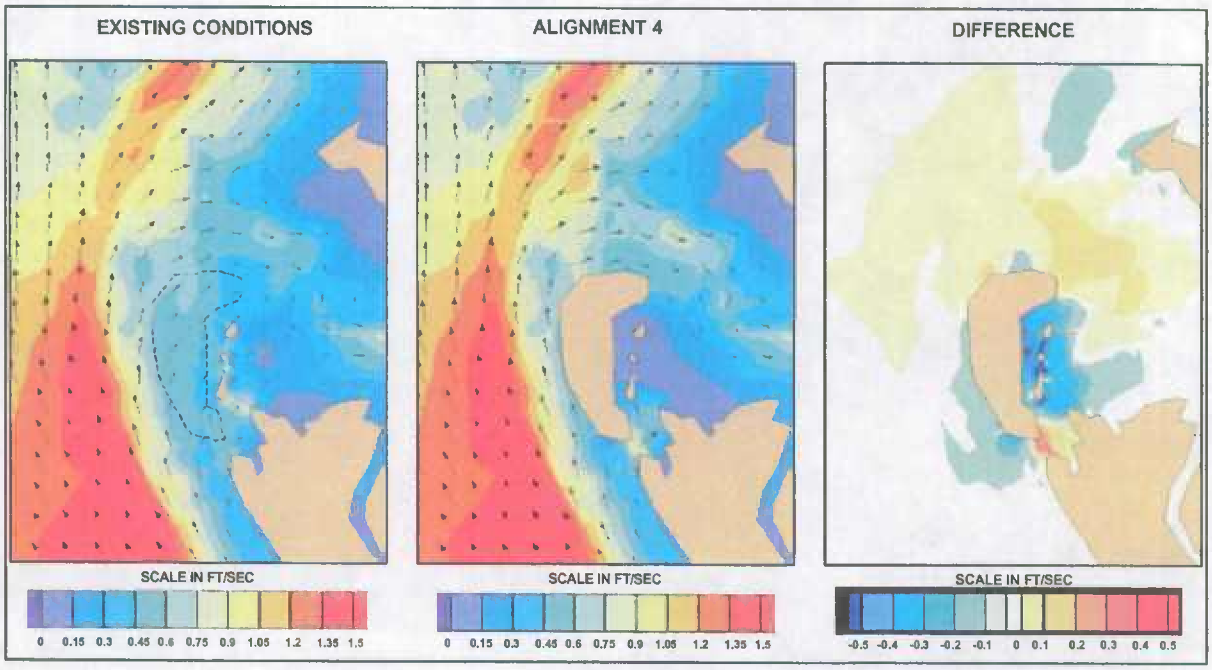


Figure 6-16: Peak Flood Current Velocity – Alignment 4 vs. Existing Conditions

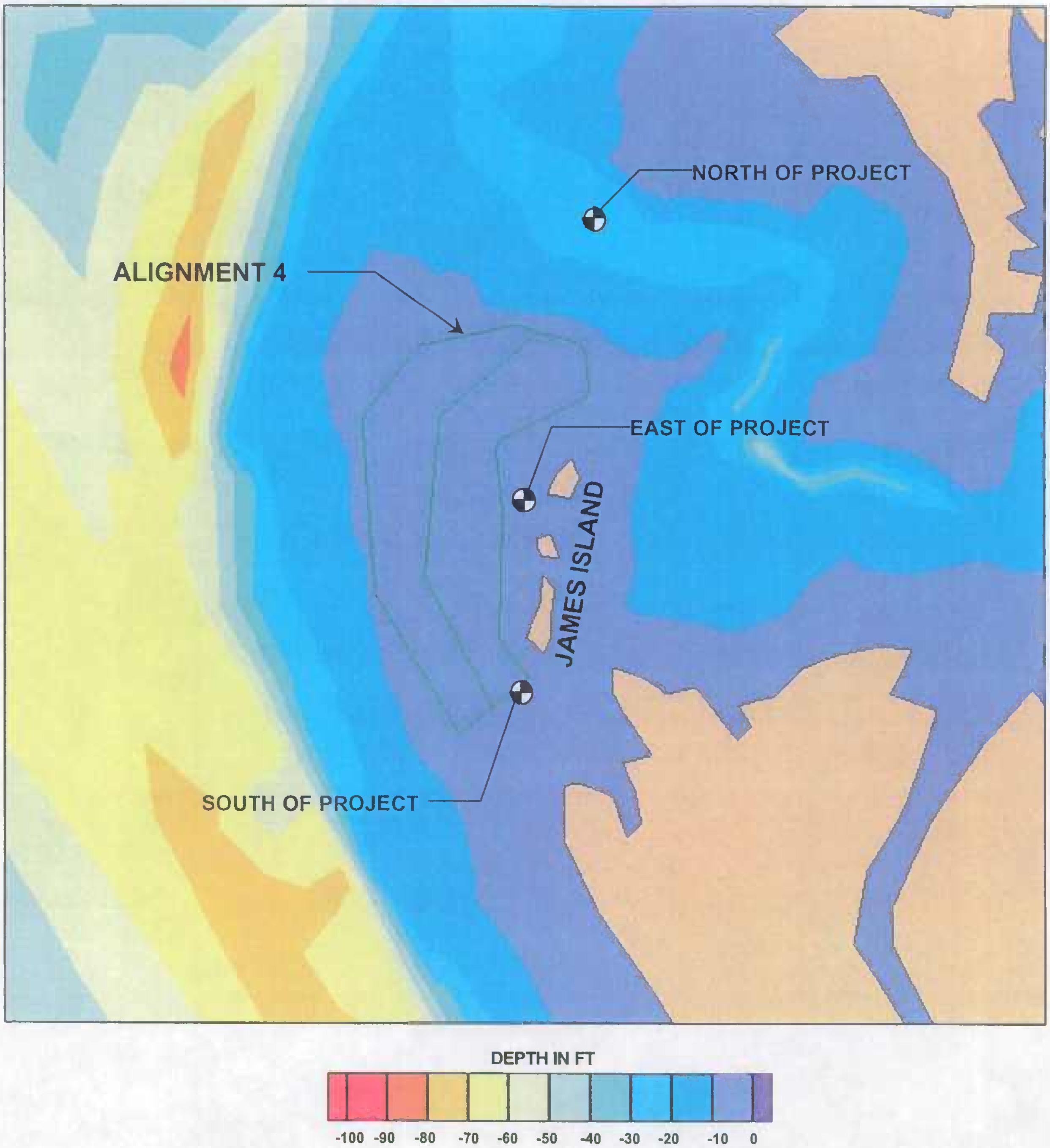


Figure 6-17: Results Comparison Locations for Alignment 5

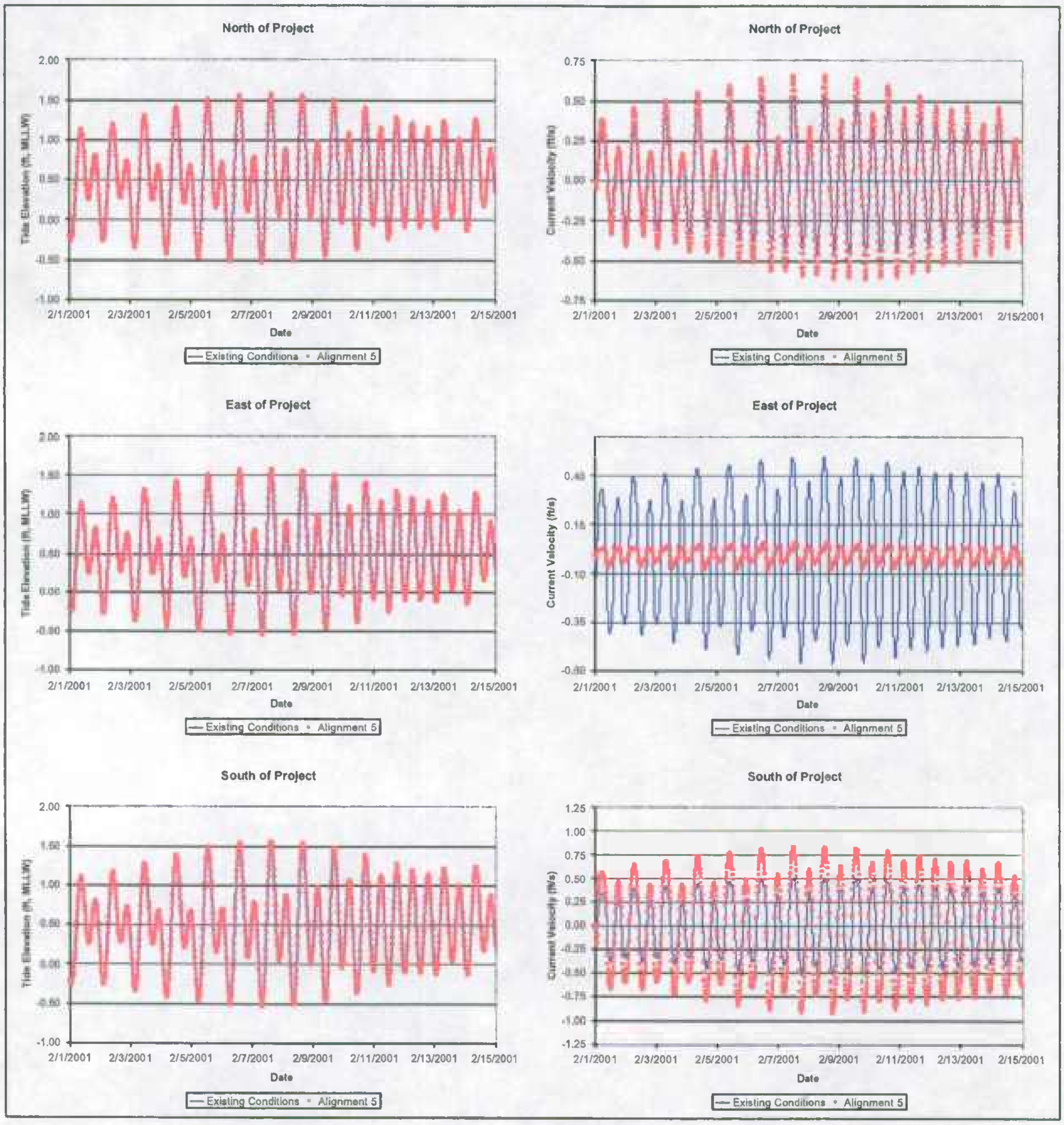


Figure 6-18: James Island Tidal Results Comparison for Alignment 5

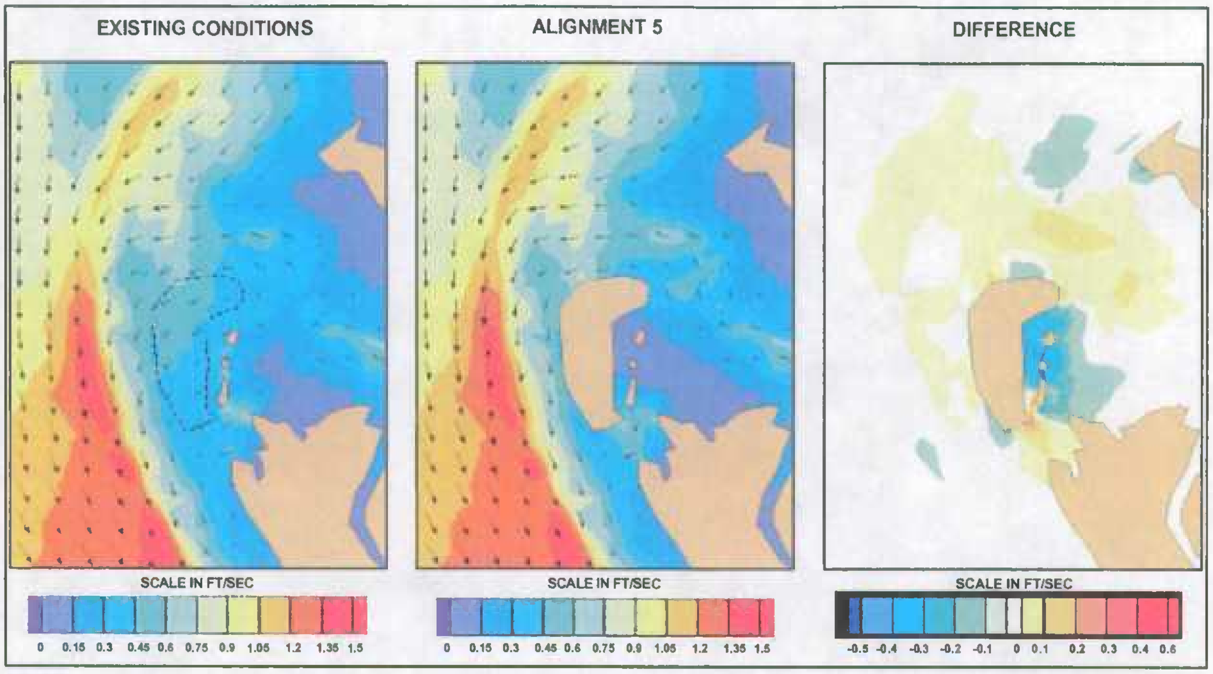


Figure 6-19: Peak Ebb Current Velocity – Alignment 5 vs. Existing Conditions

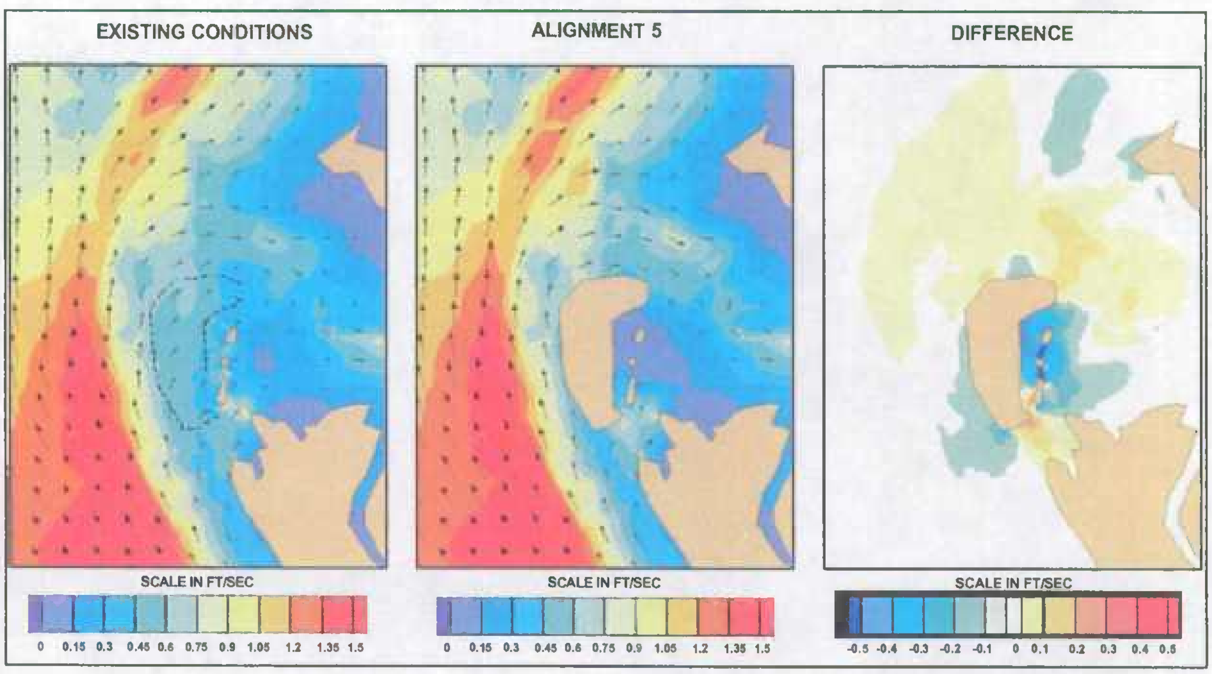


Figure 6-20: Peak Flood Current Velocity – Alignment 5 vs. Existing Conditions

7. SEDIMENTATION MODELING RESULTS

7.1 GENERAL

The UCB-FEM sedimentation model was used to examine transport of non-cohesive and cohesive materials (i.e. sand and clay) which characterize sediment in the vicinity of the project site. Detailed sediment data for the vicinity of James Island were not available so the model was used empirically by running the model to dynamic equilibrium as discussed in Section 5.3 and interpreting the results with a normalized unit scale. Examination of model results for both non-cohesive and cohesive sediments indicates that normal tidal currents are insufficient to directly cause sediment suspension and transport. Wind generated waves increase bottom shear stresses significantly and can cause sediment suspension. Various wind speeds were modeled and 16-mph winds were determined to be the minimum necessary to cause sediment suspension and transport for non-cohesive sediments. Thirteen-mph winds were the minimum necessary to cause substantial sediment suspension and transport for cohesive sediments.

Numerical modeling analyses indicate that sedimentation in the vicinity of James Island would be affected by the construction of the project. Results of the UCB-FEM sedimentation model simulations are compared visually for the entire project vicinity.

The UCB-FEM sedimentation model was run for each alignment as well as existing conditions starting each simulation with the same initial conditions. The following sections describe the impacts of each habitat construction alignment on sedimentation. Results have been normalized to a unitless scale due to the empirical use of the sedimentation model as a result of insufficient local calibration data. Cohesive sediments have properties (shape, plasticity, electric charge) that cause the particles to remain in suspension for relatively long periods of time before they settle out, resulting in a larger area affected by sedimentation and erosion than for non-cohesive sediments.

7.2 ALIGNMENT 1 IMPACTS

Non-cohesive and cohesive sediment model results for Alignment 1 are presented in Figures 7-1 through 7-6.

7.2.1 Non-Cohesive Sediment

Figures 7-1 through 7-3 show sedimentation modeling results for 0.004 inch non-cohesive sediments for 16-mph NNW, SSE and WNW winds, respectively. Comparison of sedimentation patterns with bathymetry shows that the areas of erosion correspond to shallow water depths while deposition occurs in adjacent deep water areas.

Construction of Alignment 1 would interrupt the long NNW wind fetch from across the Bay, thereby reducing erosion in the project area as shown in Figure 7-1. Figure 7-1 shows a large area south of the project extending to and along the shoreline of Taylors Island where erosion of the shallow water is reduced. The difference plot of Figure 7-1 shows a yellow to orange area (labeled more sediment on the scale) that represents areas that are eroding under existing conditions would have reduced or no erosion for the with-project conditions.

For winds from the SSE, construction of Alignment 1 would also interrupt a large portion of the long wind fetch, reducing the rates of erosion and accretion at James Island as shown in the difference plot of Figure 7-2. The orange to red region along the west dike labeled as more sediment represents an area that is currently eroding would become an accretion area. The difference plot also shows areas labeled less sediment (green) where accretion is reduced that is due to the reduced erosion of the shallow areas, and subsequently less sediment in the water column.

Figure 7-3 shows results from construction of Alignment 1 for winds from the WNW. This figure shows that less erosion occurs for these winds, as the fetch length is much less. The with-project plot and difference plot in Figure 7-3 shows reduced erosion of areas around James Island and near the northern tip of Taylors Island.

7.2.2 Cohesive Sediment

Figures 7-4 through 7-6 show sedimentation modeling results for cohesive sediments for 13-mph NNW, SSE, and WNW winds, respectively. Figure 7-4 shows a significant reduction in erosion in the project area following construction, plus significantly more sediment accretion in the lee of the project, extending south to Taylors Island. Of interest to note in the difference plot is a bluish area labeled less sediment southeast of James Island, which is actually a reduction in accretion. Figure 7-5 shows modeling results for 13-mph SSE winds. The difference plot in this figure shows that north of the project some areas have less erosion and some areas have accretion. Figure 7-6 shows modeling results for 13-mph WNW winds. This figure shows that current erosion around James Island would essentially be eliminated.

7.3 ALIGNMENT 2 IMPACTS

Non-cohesive and cohesive sediment model results for Alignment 2 are presented in Figures 7-7 through 7-12.

7.3.1 Non-Cohesive Sediment

Figures 7-7 through 7-9 show sedimentation modeling results for 0.004 inch non-cohesive sediments for 16-mph NNW, SSE and WNW winds, respectively. Comparison of sedimentation patterns with bathymetry shows that the areas of erosion correspond to shallow water depths while deposition occurs in adjacent deep water areas.

Construction of Alignment 2 provides the most protection to James Island from the long NNW wind fetch from across the Bay, preventing erosion in the lee of the project as shown in Figure 7-7. Figure 7-7 shows that the large area south of the project extending to and along the shoreline of Taylors Island where erosion would be reduced upon construction of Alignment 1 is completely eliminated upon construction of Alignment 2. This is because Alignment 2 extends further to the west. The difference plot of Figure 7-7 shows that areas that are accreting under existing conditions would either erode or accrete less along the dikes exposed to the N, NW and W.

For winds from the SSE, construction of Alignment 2 would also interrupt a large portion of the long wind fetch, reducing the rates of erosion in the shallows around James Island. This results in reduced accretion, as indicated by the less sediment area as shown in the difference plot of Figure 7-8. Figure 7-9 shows results from construction of Alignment 2 for winds from the WNW. As for Alignment 1, this figure shows that less erosion occurs for these winds, as the fetch length is much less. The with-project plot and difference plot in Figure 7-9 shows reduced erosion of areas around James Island and near the northern tip of Taylors Island.

7.3.2 Cohesive Sediment

Figures 7-10 through 7-12 show sedimentation modeling results for cohesive sediments for 13-mph NNW, SSE, and WNW winds, respectively. Figure 7-10 shows a significant reduction in erosion in the project area following construction, plus significantly more sediment accretion in the lee of the project, extending south to Taylors Island. This area is greater than expected for Alignment 1 as shown by the difference plot. Similarly to Alignment 1, in the difference plot is a bluish area labeled less sediment southeast James Island, which is actually a reduction in accretion. Figure 7-11 shows modeling results for 13-mph SSE winds. The difference plot in this figure shows less erosion in addition to accretion north of the project, plus reduced accretion east of the project. Once again, the area of impact is greater than for Alignment 1, although not to the same extent as for NNW winds. Figure 7-12 shows modeling results for 13-mph WNW winds. This figure shows that current erosion around James Island would essentially be eliminated.

7.4 ALIGNMENT 3 IMPACTS

Non-cohesive and cohesive sediment model results for Alignment 3 are presented in Figures 7-13 through 7-18.

7.4.1 Non-Cohesive Sediment

Figures 7-13 through 7-15 show sedimentation modeling results for 0.004 inch non-cohesive sediments for 16-mph NNW, SSE and WNW winds, respectively. Comparison of sedimentation patterns with bathymetry shows that the areas of erosion correspond to shallow water depths while deposition occurs in adjacent deep water areas.

Construction of Alignment 3 would interrupt the long NNW wind fetch from across the Bay, thereby reducing erosion in the project area as shown in Figure 7-13. Figure 7-13 shows a large area south of the project extending to and along the shoreline of Taylors Island where erosion of the shallow water is reduced. Erosion would still occur along the west dikes of the project.

For winds from the SSE, construction of Alignment 3 would also interrupt a large portion of the long wind fetch, reducing the rates of erosion and accretion around James Island as shown in the difference plot of Figure 7-14. The orange to red region along the west dike labeled as more sediment represents an area that is currently eroding would become an accretion area. The difference plot also shows areas labeled less sediment (green) where accretion is reduced that is due to the reduced erosion of the shallow areas, and subsequently less sediment in the water column.

Figure 7-15 shows results from construction of Alignment 3 for winds from the WNW. This figure shows that less erosion occurs for these winds, as the fetch length is much less. Similar to the other two alignments, the with-project plot and difference plot in Figure 7-15 shows reduced erosion of areas around James Island and near the northern tip of Taylors Island.

7.4.2 Cohesive Sediment

Figures 7-16 through 7-18 show sedimentation modeling results for cohesive sediments for 13-mph NNW, SSE, and WNW winds, respectively. Figure 7-16 shows a significant reduction in erosion in the project area following construction, plus significantly more sediment accretion in the lee of the project, extending south to Taylors Island. This is similar to Alignment 1, where in the difference plot the bluish area labeled less sediment southeast James Island, which is actually a reduction in accretion. Figure 7-17 shows modeling results for 13-mph SSE winds. The difference plot in this figure shows less erosion in addition to accretion north of the project, plus reduced accretion east of the project. Figure 7-18 shows modeling results for 13-mph WNW winds. As for the other two alignments, erosion around James Island due to WNW winds would essentially be eliminated.

7.5 ALIGNMENT 4 IMPACTS

Non-cohesive and cohesive sediment model results for Alignment 4 are presented in Figures 7-19 through 7-24.

7.5.1 Non-Cohesive Sediment

Figures 7-19 through 7-21 show sedimentation modeling results for 0.004 inch non-cohesive sediments for 16-mph NNW, SSE and WNW winds, respectively. Comparison of sedimentation patterns with bathymetry shows that the areas of erosion correspond to shallow water depths while deposition occurs in adjacent deep water areas. Sedimentation changes due to construction of this alignment are similar to that for Alignment 2 and 5.

Construction of Alignment 4 would interrupt the long NNW wind fetch from across the Bay, thereby reducing erosion in the project area as shown in Figure 7-19. Figure 7-19 shows a large area south of the project extending to and along the shoreline of Taylors Island where erosion of the shallow water is reduced. The difference plot of Figure 7-19 shows a yellow to orange area (labeled more sediment on the scale) that represents areas that are eroding under existing conditions would have reduced or no erosion for the with-project conditions.

For winds from the SSE, construction of Alignment 4 would also interrupt a large portion of the long wind fetch, reducing the rates of erosion and accretion James Island as shown in the difference plot of Figure 7-20. The orange to red region along the west dike labeled as more sediment represents an area that is currently eroding would become an accretion area. The difference plot also shows areas labeled less sediment (green) where accretion is reduced that is due to the reduced erosion of the shallow areas, and subsequently less sediment in the water column.

Figure 7-21 shows results from construction of Alignment 4 for winds from the WNW. This figure shows that less erosion occurs for these winds, as the fetch length is much less. Similar to the other alignments, the with-project plot and difference plot in Figure 7-15 shows reduced erosion of areas around James Island and near the north tip of Taylors Island.

7.5.2 Cohesive Sediment

Figures 7-22 through 7-24 show sedimentation modeling results for cohesive sediments for 13-mph NNW, SSE, and WNW winds, respectively. Figure 7-22 shows a significant reduction in erosion in the project area following construction, plus significantly more sediment accretion in the lee of the project, extending south to Taylors Island. Results are similar to Alignment 2, but over less area. The same bluish area southeast of James Island labeled less sediment is a reduction in accretion. Figure 7-23 shows modeling results for 13-mph SSE winds. The difference plot in this figure shows less erosion in addition to accretion north of the project, plus reduced accretion east of the project. Figure 7-24 shows modeling results for 13-mph WNW winds, which also show that current erosion around James Island would essentially be eliminated.

7.6 ALIGNMENT 5 IMPACTS

Non-cohesive and cohesive sediment model results for Alignment 5 are presented in Figures 7-25 through 7-30.

7.6.1 Non-Cohesive Sediment

Figures 7-25 through 7-27 show sedimentation modeling results for 0.004 inch non-cohesive sediments for 16-mph NNW, SSE and WNW winds, respectively. Comparison of sedimentation patterns with bathymetry shows that the areas of erosion correspond to shallow water depths while deposition occurs in adjacent deep water areas. Sedimentation changes are similar to Alignment 2 and 4.

Construction of Alignment 5 would interrupt the long NNW wind fetch from across the Bay, thereby reducing erosion in the project area as shown in Figure 7-25. Figure 7-25 shows a large area south of the project extending to and along the shoreline of Taylors Island where erosion of the shallow water is reduced. The difference plot of Figure 7-25 shows a yellow to orange area (labeled more sediment on the scale) that represents areas that are eroding under existing conditions would have no erosion for the with-project conditions.

For winds from the SSE, construction of Alignment 5 would also interrupt a large portion of the long wind fetch, reducing the rates of erosion and accretion James Island as shown in the difference plot of Figure 7-26. The orange to red region along the west dike labeled as more sediment represents an area that is currently eroding would become an accretion area. The difference plot also shows areas labeled less sediment (green and blue) where accretion is reduced that is due to the reduced erosion of the shallow areas, and subsequently less sediment in the water column.

Figure 7-27 shows results from construction of Alignment 5 for winds from the WNW. Results are similar to the previous alignments and show reduced erosion of areas around James Island and near the northern tip of Taylors Island.

7.6.2 Cohesive Sediment

Figures 7-28 through 7-30 show sedimentation modeling results for cohesive sediments for 13-mph NNW, SSE, and WNW winds, respectively. Figure 7-28 shows a significant reduction in erosion in the project area following construction, plus significantly more sediment accretion in the lee of the project, extending south to Taylors Island. Similar to all alignments, the difference plot shows a bluish area labeled less sediment southeast James Island that is a reduction in accretion. Figure 7-29 shows modeling results for 13-mph SSE winds. The difference plot in this figure shows less erosion in addition to accretion north of the project, plus reduced accretion east of the project. Figure 7-30 shows modeling results for 13-mph WNW winds that indicate erosion around James Island would essentially be eliminated.

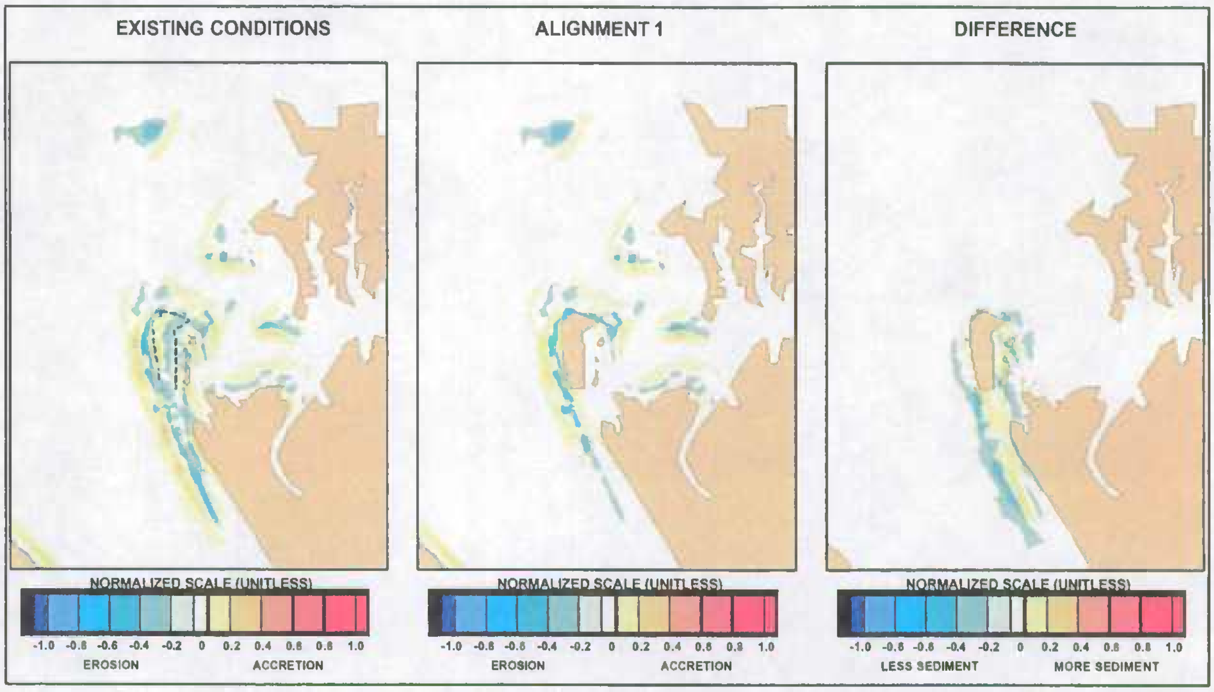


Figure 7-1: Non-Cohesive Sediment – North-Northwest Wind 16 mph – Alignment 1 vs. Existing Conditions

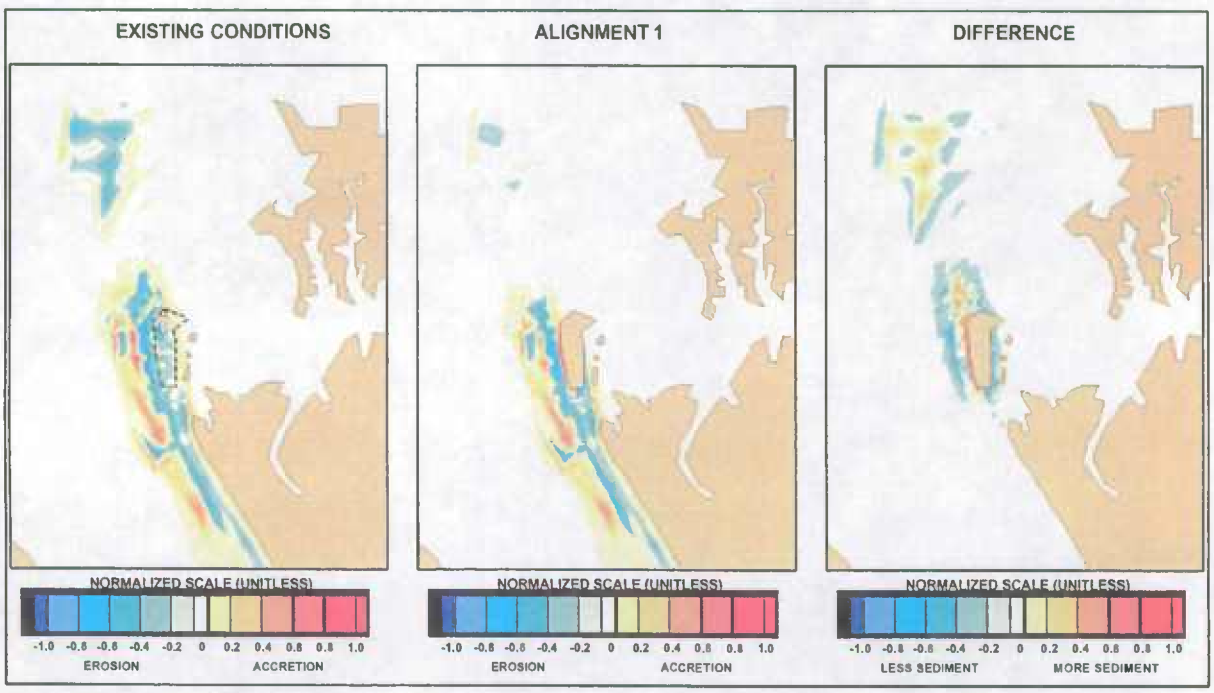


Figure 7-2: Non-Cohesive Sediment – South-Southeast Wind 16 mph – Alignment 1 vs. Existing Conditions

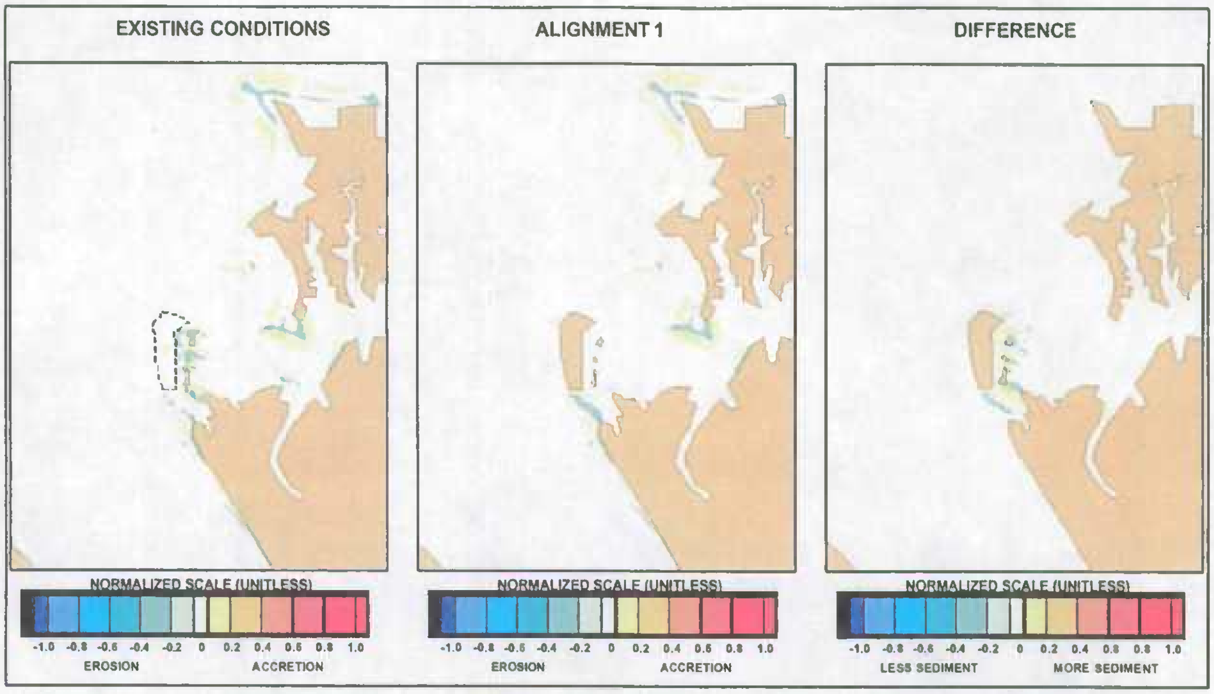


Figure 7-3: Non-Cohesive Sediment – West -Northwest Wind 16 mph – Alignment 1 vs. Existing Conditions

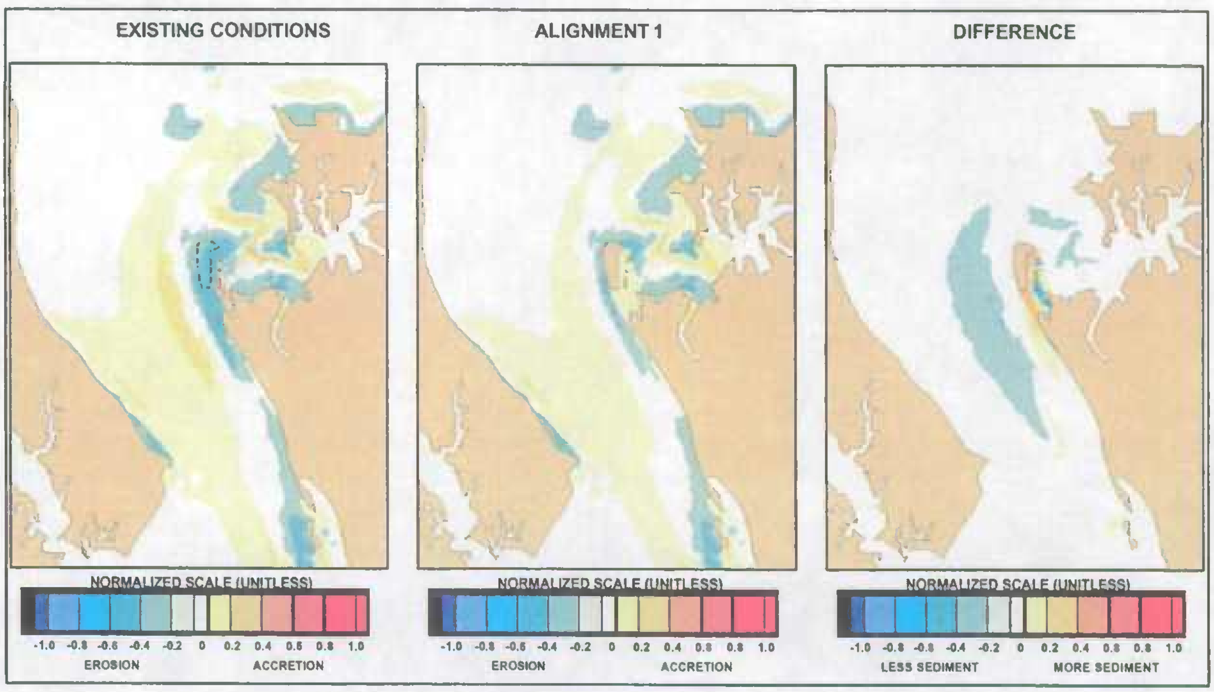


Figure 7-4: Cohesive Sediment – North-Northwest Wind 13 mph Alignment 1 vs. Existing Conditions

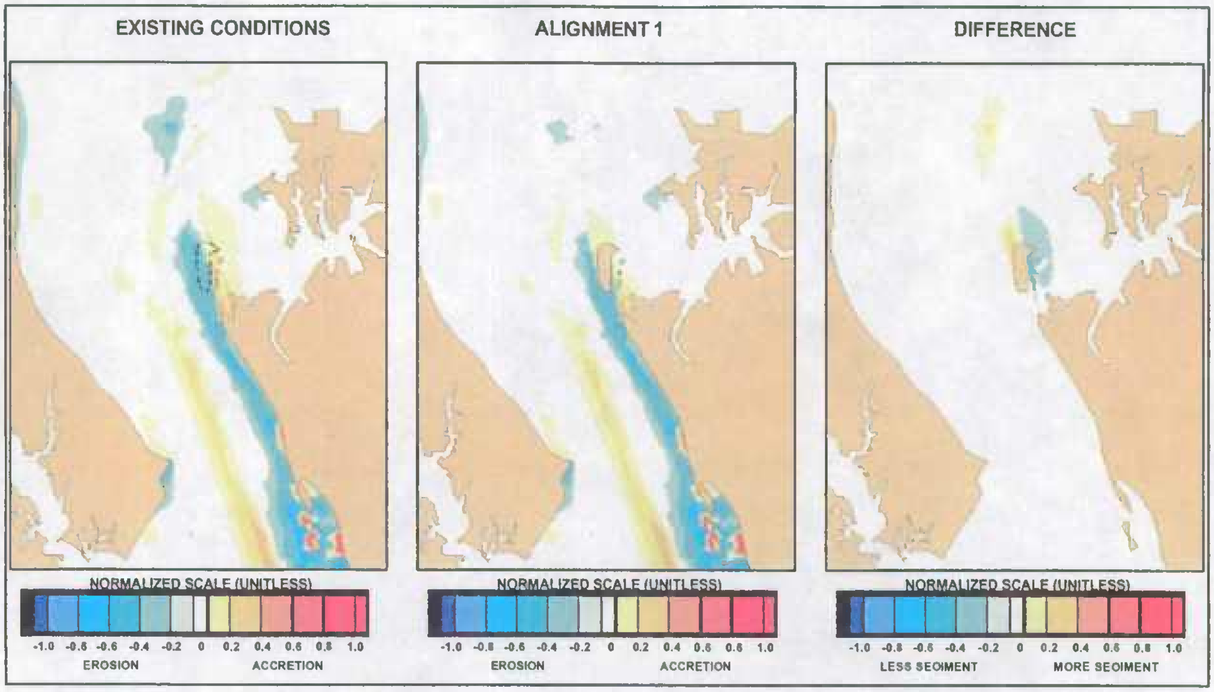


Figure 7-5: Cohesive Sediment – South-Southeast Wind 13 mph – Alignment 1 vs. Existing Conditions

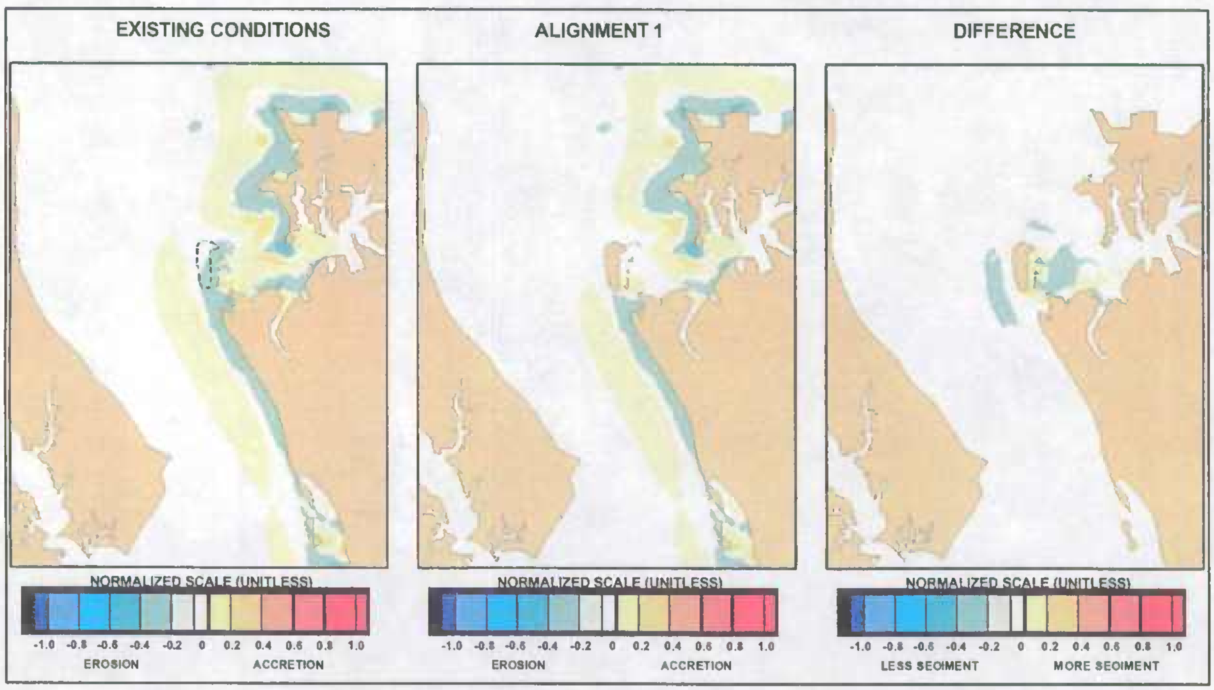


Figure 7-6: Cohesive Sediment – West-Northwest Wind 13 mph – Alignment 1 vs. Existing Conditions

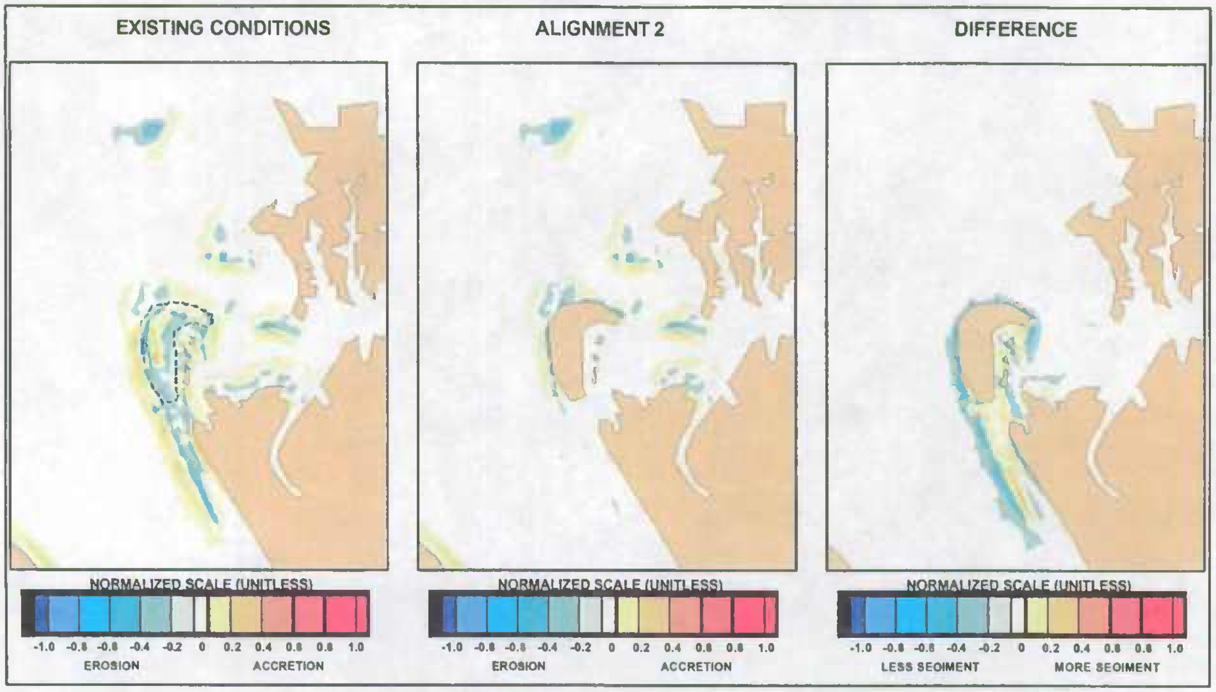


Figure 7-7: Non-Cohesive Sediment – North-Northwest Wind 16 mph – Alignment 2 vs. Existing Conditions

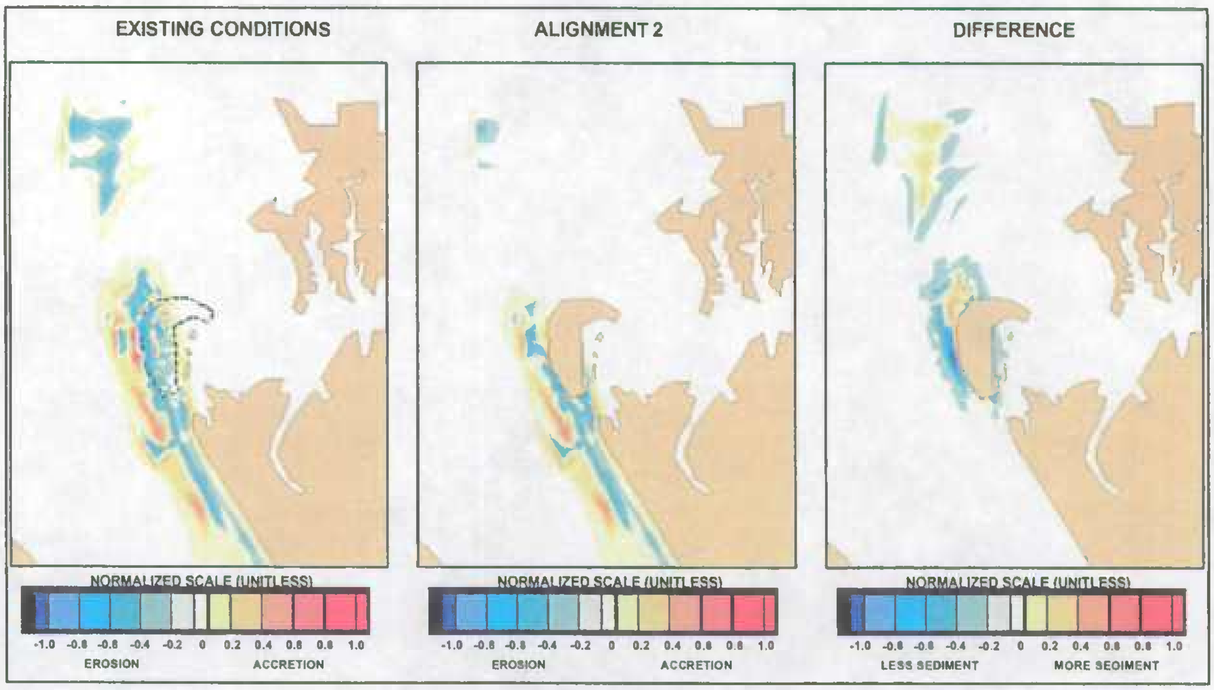


Figure 7-8: Non-Cohesive Sediment – South-Southeast Wind 16 mph – Alignment 2 vs. Existing Conditions

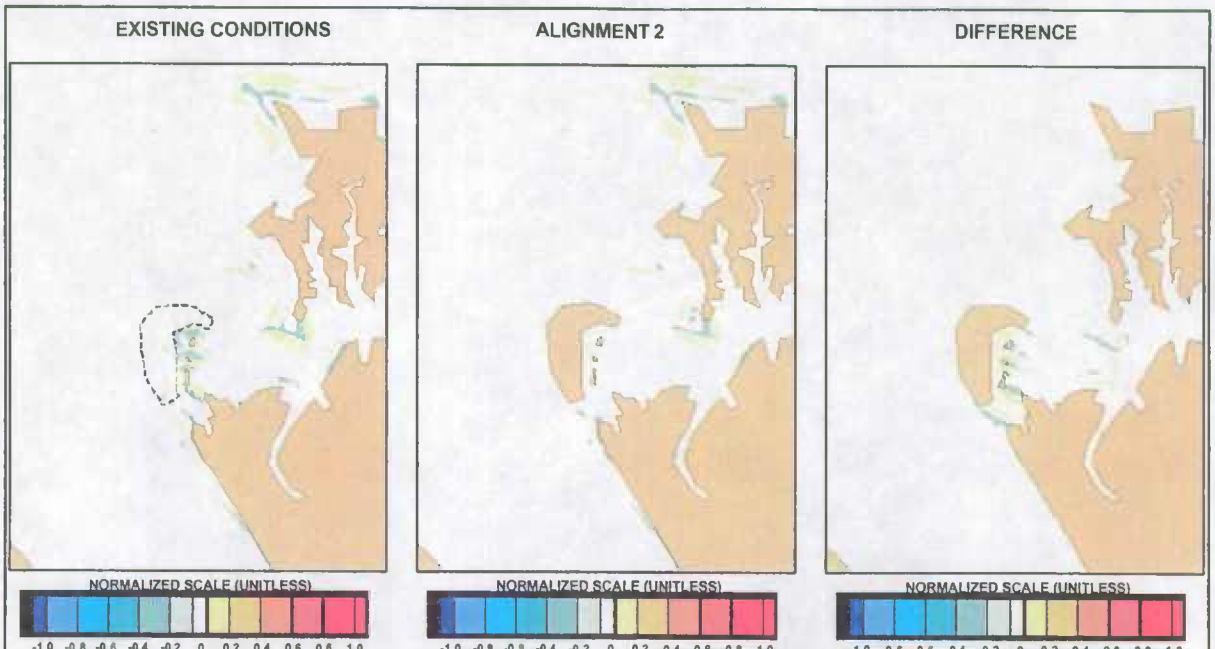


Figure 7-9: Non-Cohesive Sediment – West -Northwest Wind 16 mph – Alignment 2 vs. Existing Conditions

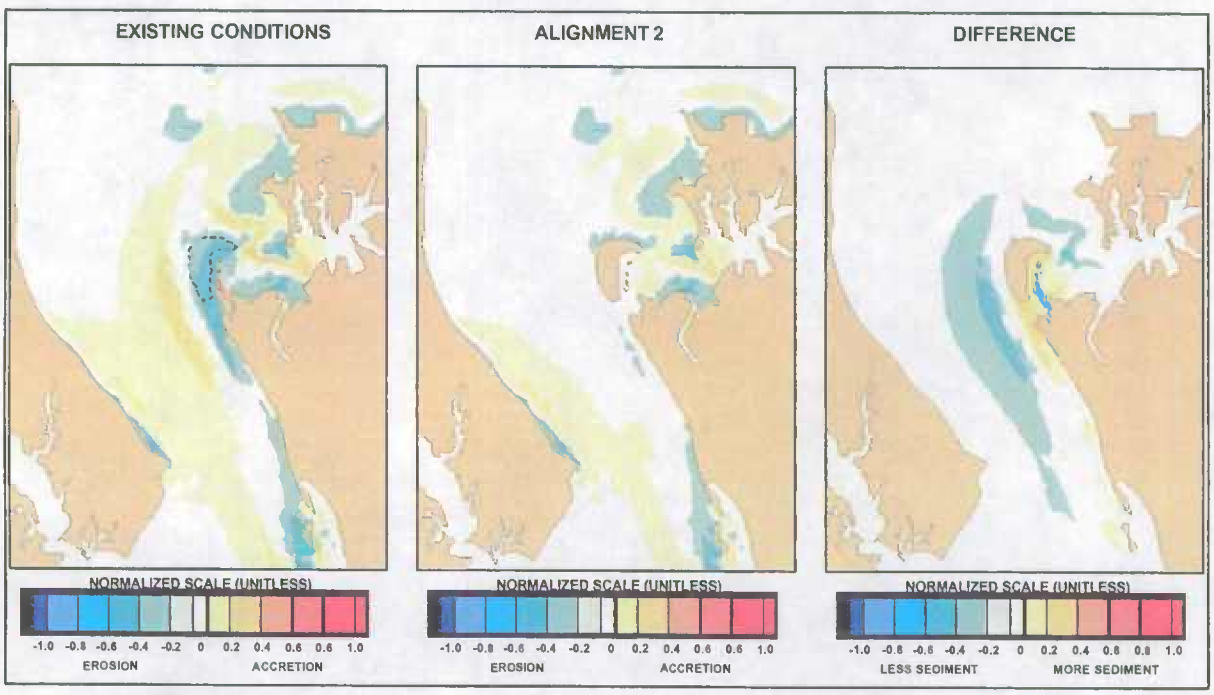


Figure 7-10: Cohesive Sediment – North-Northwest Wind 13 mph Alignment 2 vs. Existing Conditions

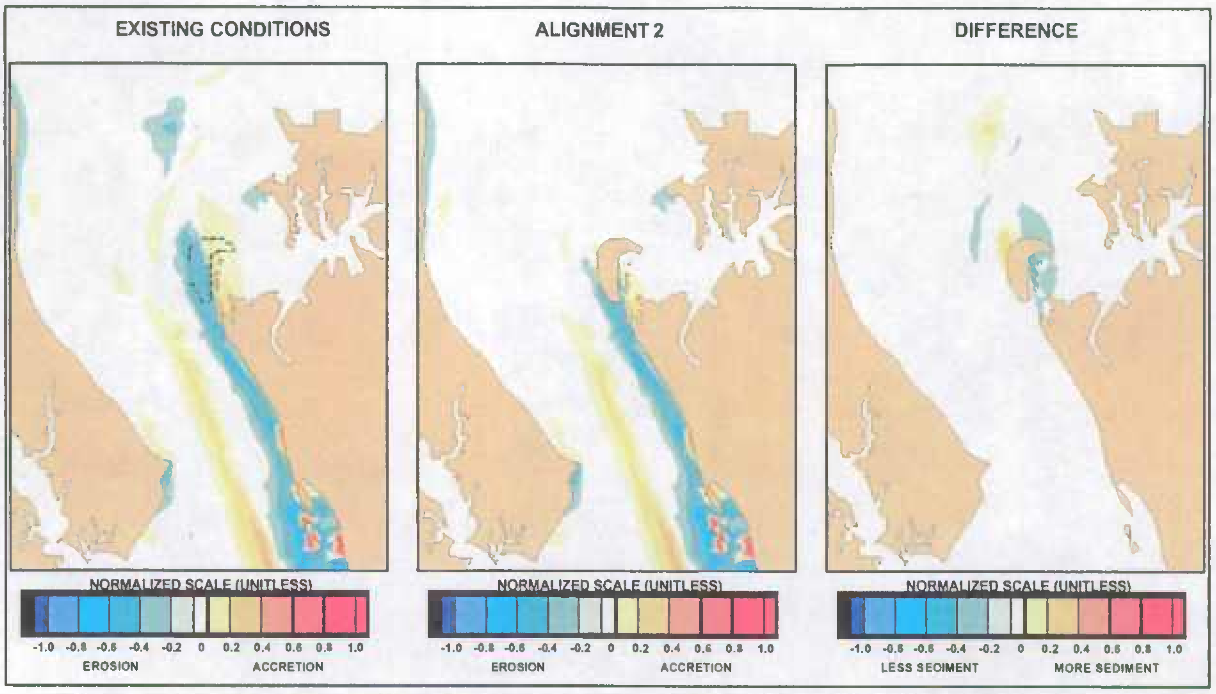


Figure 7-11: Cohesive Sediment – South-Southeast Wind 13 mph – Alignment 2 vs. Existing Conditions

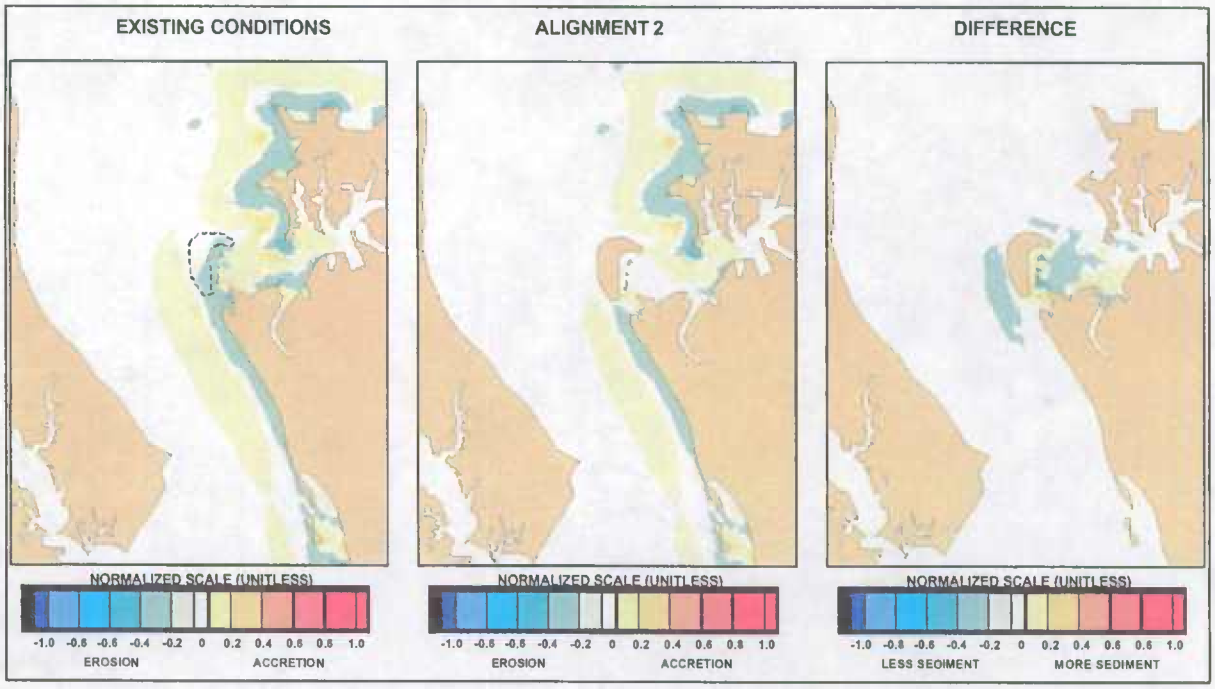


Figure 7-12: Cohesive Sediment – West-Northwest Wind 13 mph – Alignment 2 vs. Existing Conditions

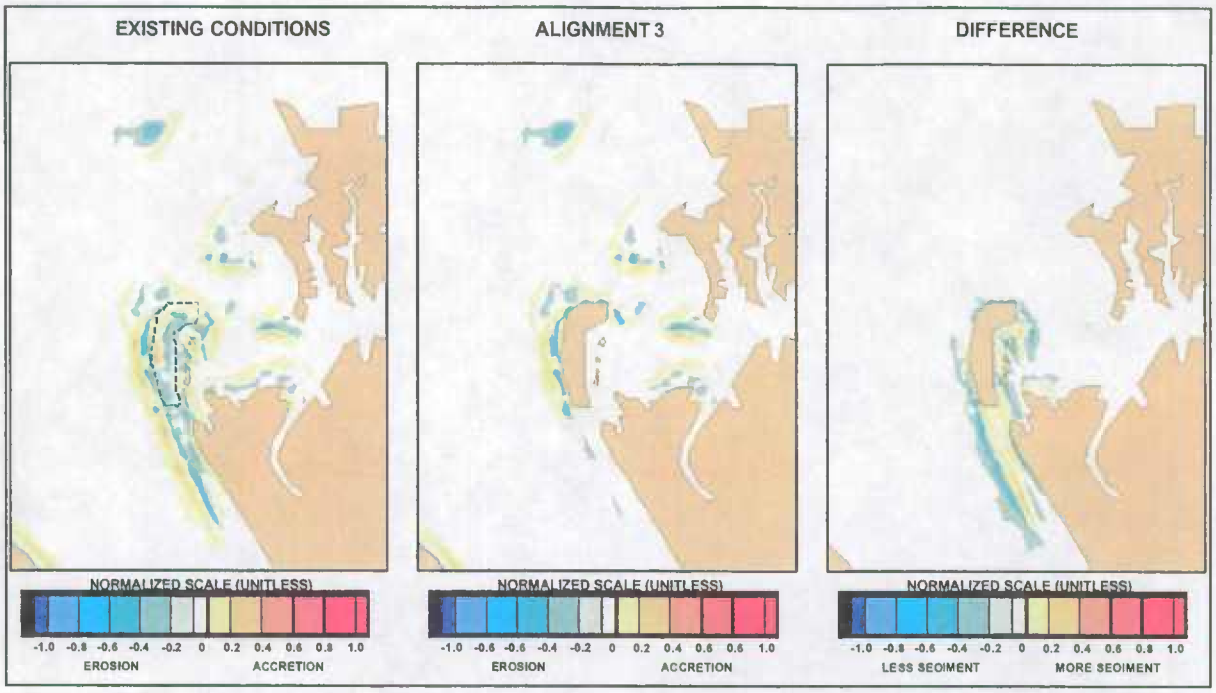


Figure 7-13: Non-Cohesive Sediment – North-Northwest Wind 16 mph – Alignment 3 vs. Existing Conditions

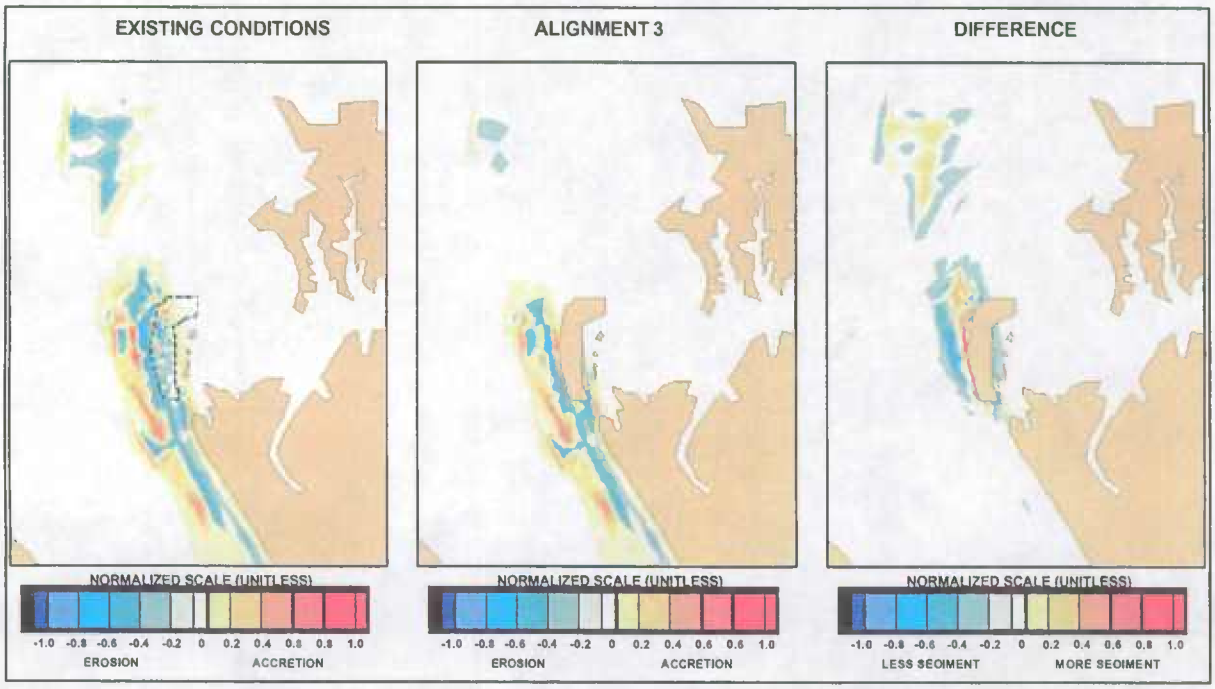


Figure 7-14: Non-Cohesive Sediment – South-Southeast Wind 16 mph – Alignment 3 vs. Existing Conditions

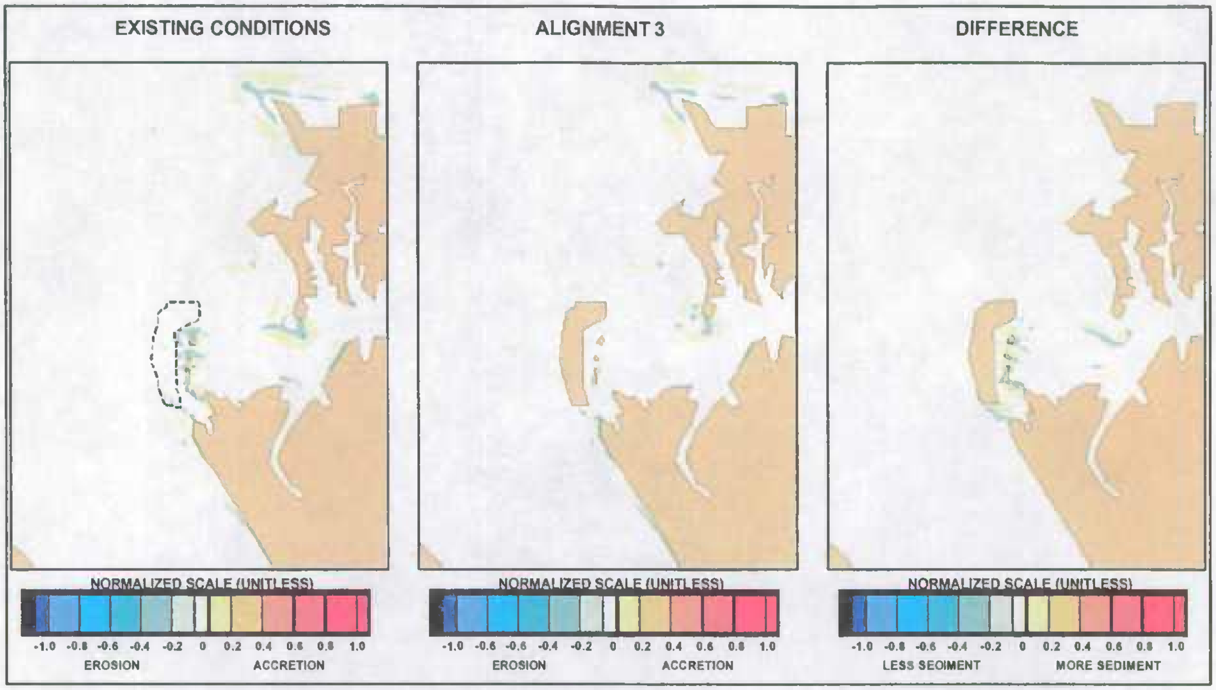


Figure 7-15: Non-Cohesive Sediment – West -Northwest Wind 16 mph – Alignment 3 vs. Existing Conditions

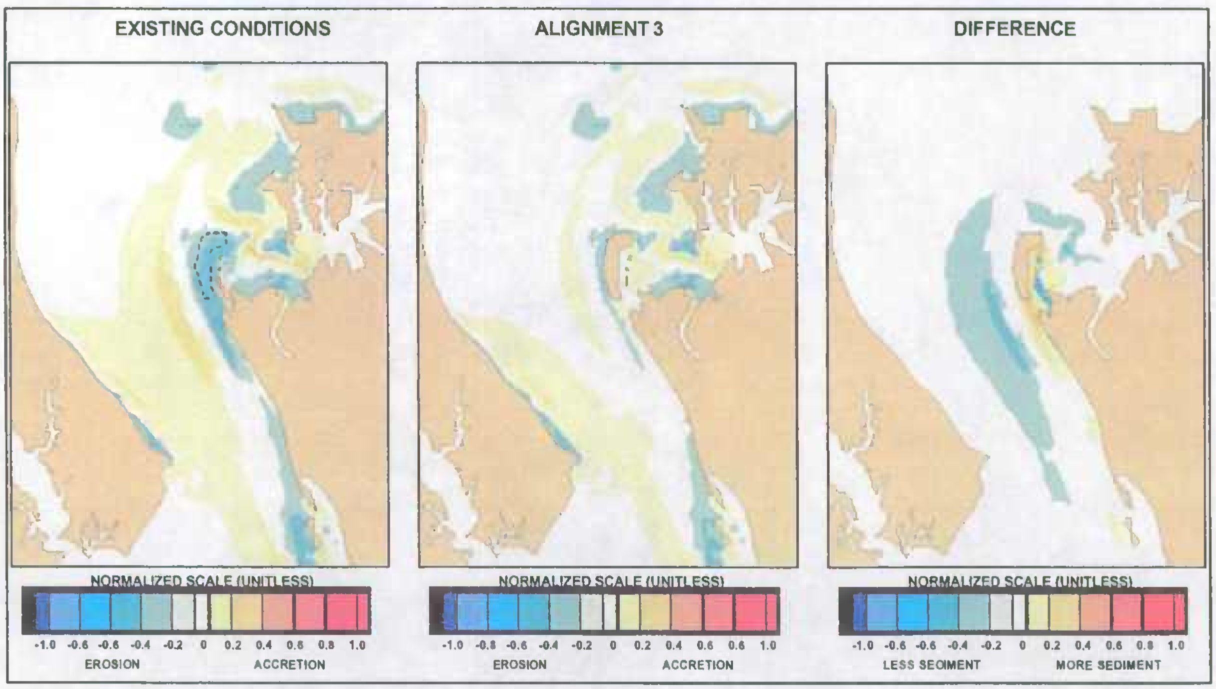


Figure 7-16: Cohesive Sediment – North-Northwest Wind 13 mph Alignment 3 vs. Existing Conditions

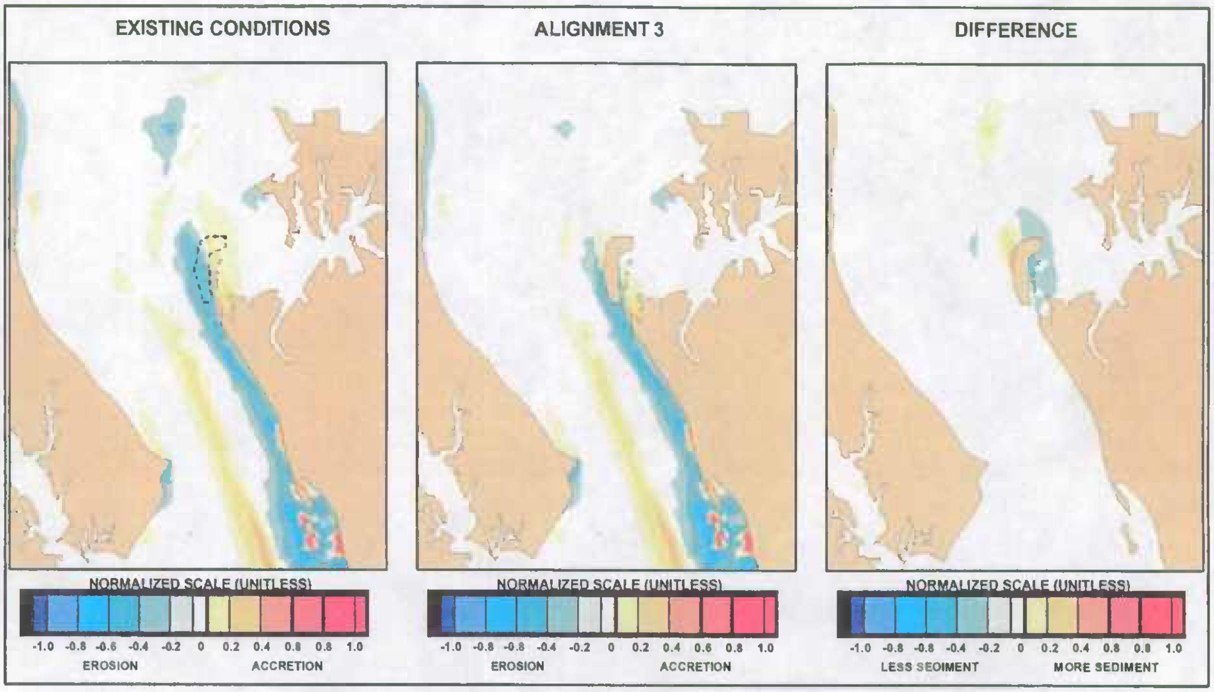


Figure 7-17: Cohesive Sediment – South-Southeast Wind 13 mph – Alignment 3 vs. Existing Conditions

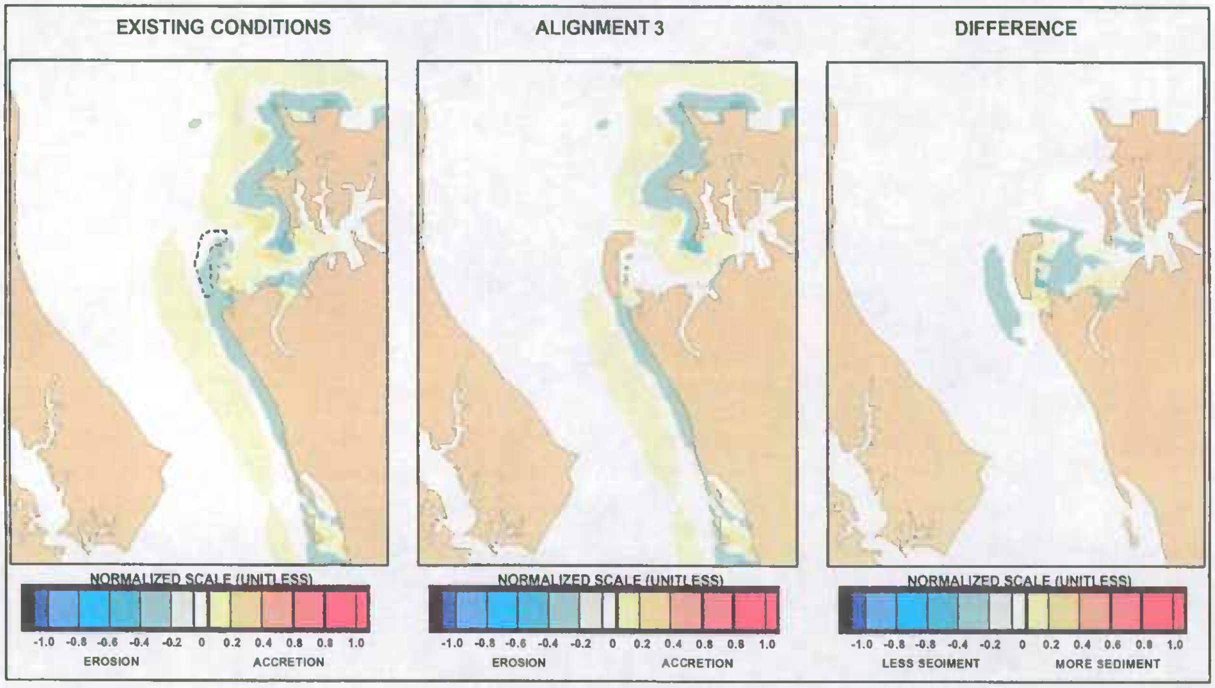


Figure 7-18: Cohesive Sediment – West-Northwest Wind 13 mph – Alignment 3 vs. Existing Conditions

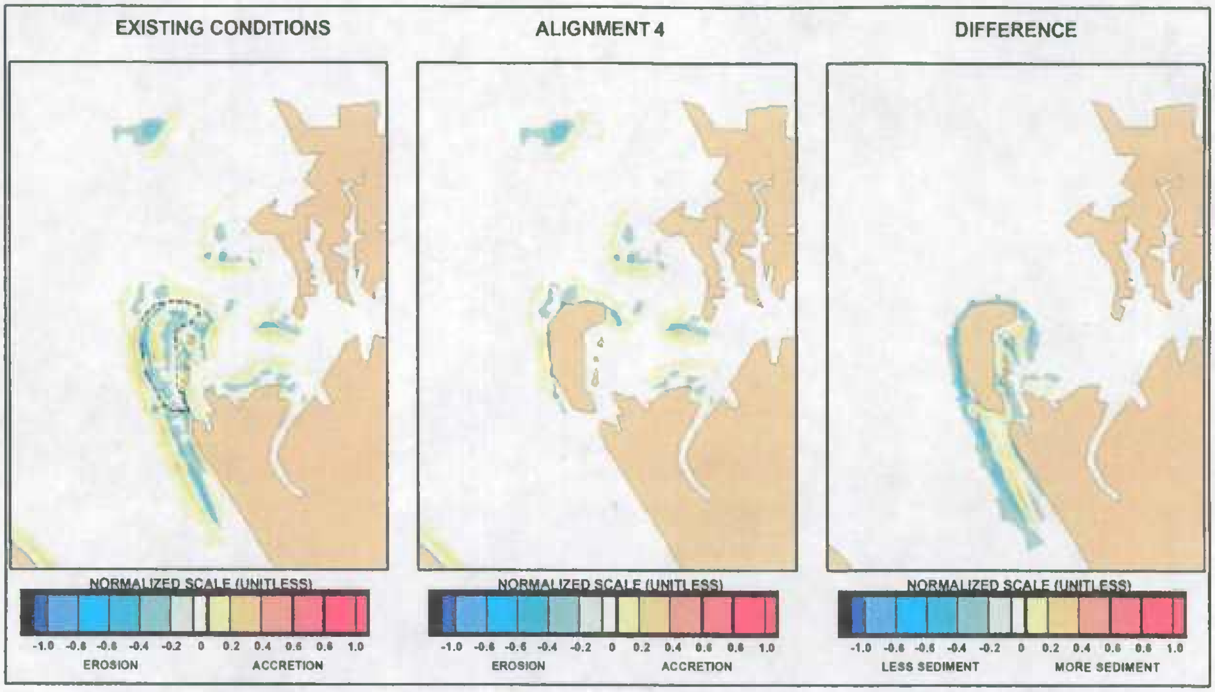


Figure 7-19: Non-Cohesive Sediment – North-Northwest Wind 16 mph – Alignment 4 vs. Existing Conditions

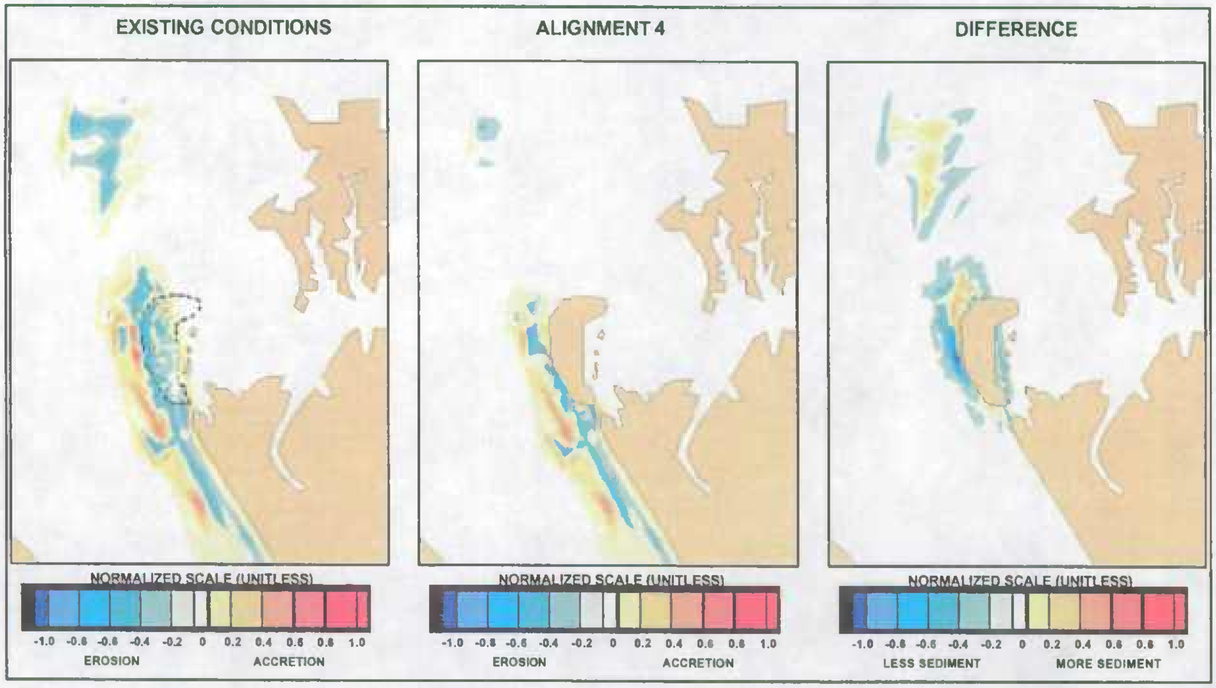


Figure 7-20: Non-Cohesive Sediment – South-Southeast Wind 16 mph – Alignment 4 vs. Existing Conditions

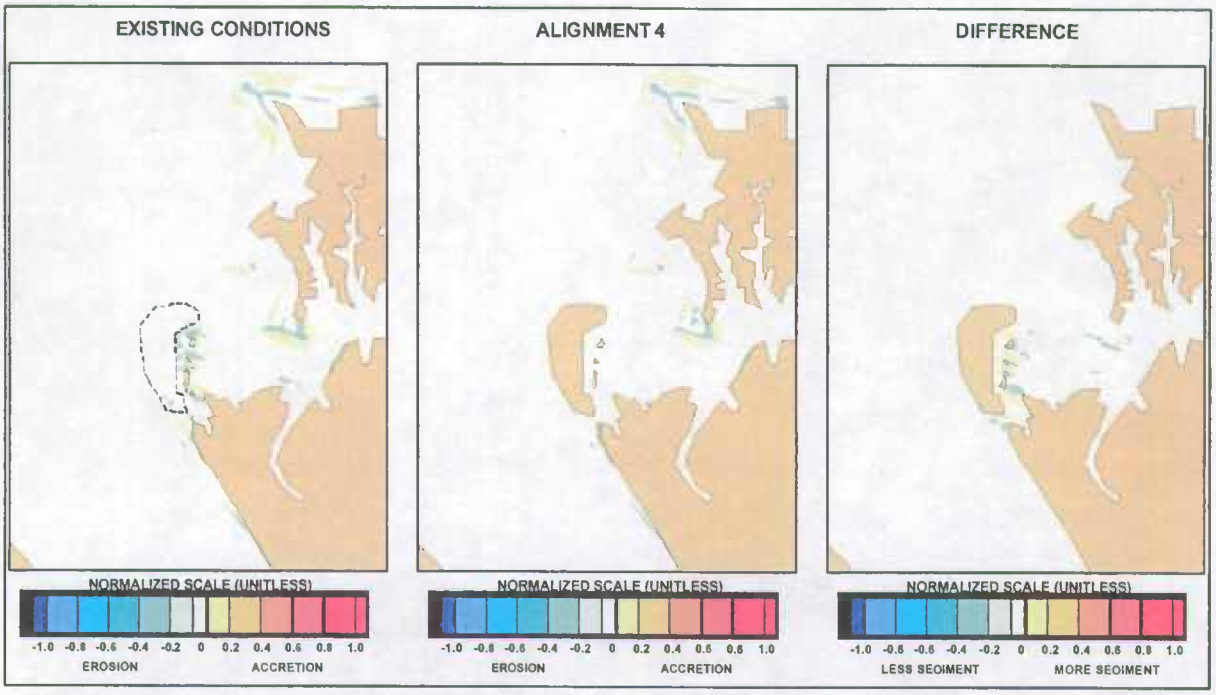


Figure 7-21: Non-Cohesive Sediment – West -Northwest Wind 16 mph – Alignment 4 vs. Existing Conditions

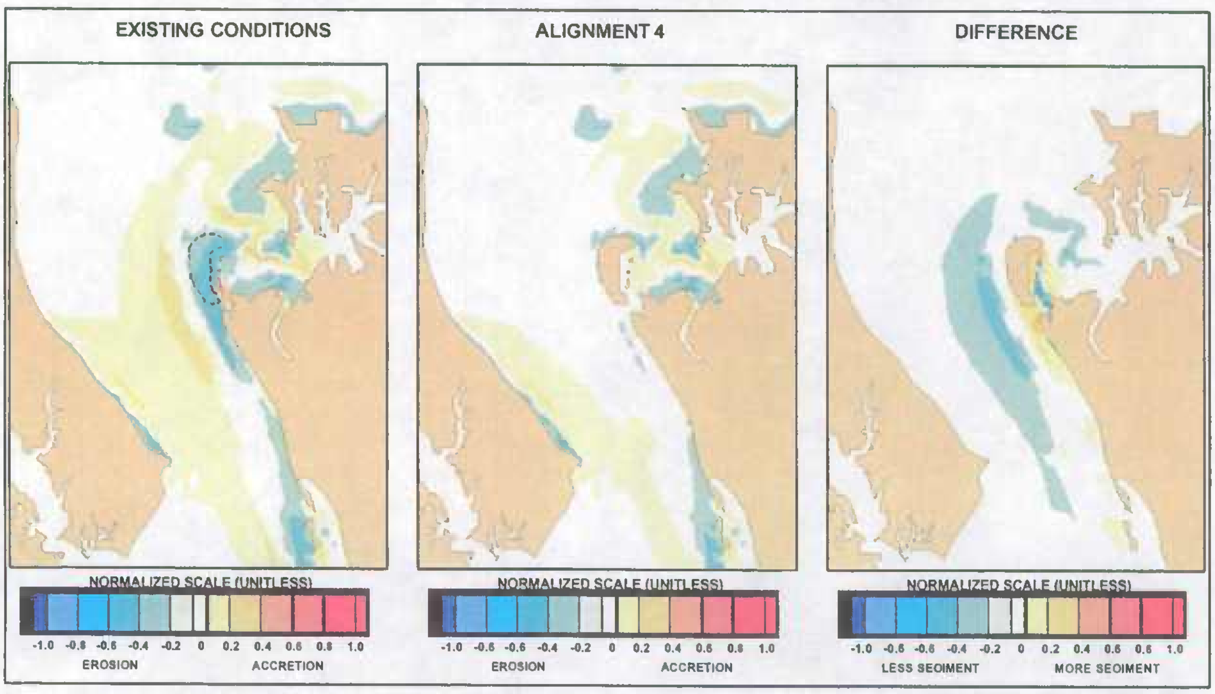


Figure 7-22: Cohesive Sediment – North-Northwest Wind 13 mph Alignment 4 vs. Existing Conditions

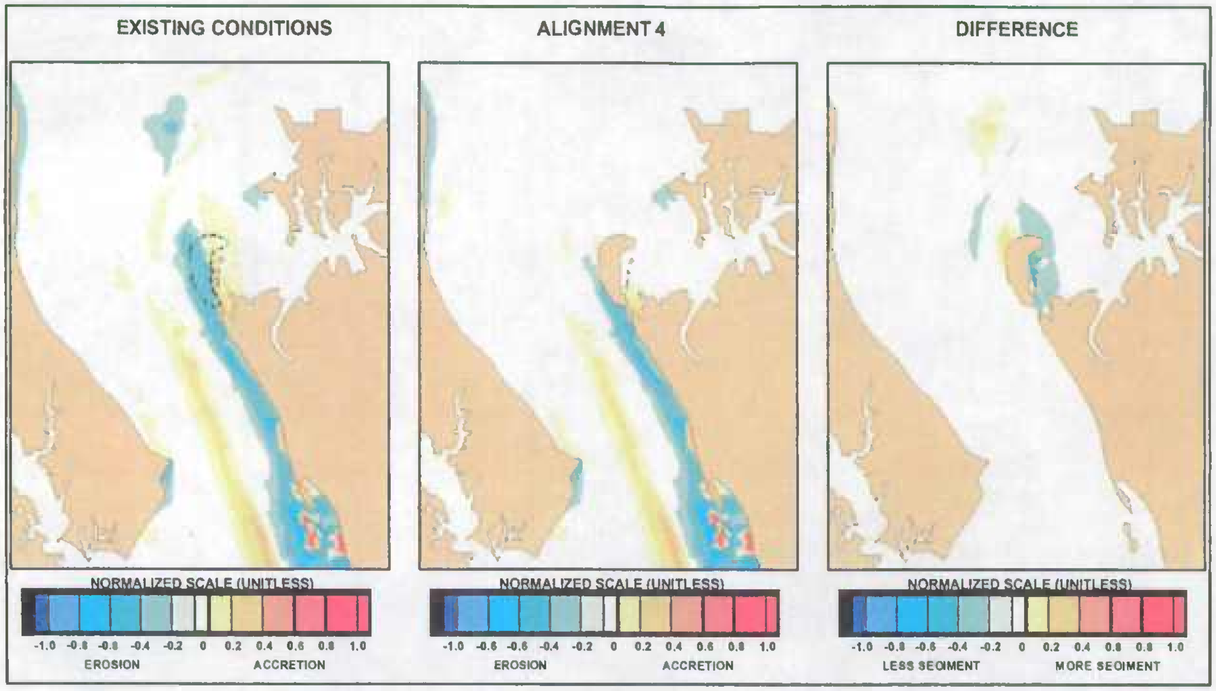


Figure 7-23: Cohesive Sediment – South-Southeast Wind 13 mph – Alignment 4 vs. Existing Conditions

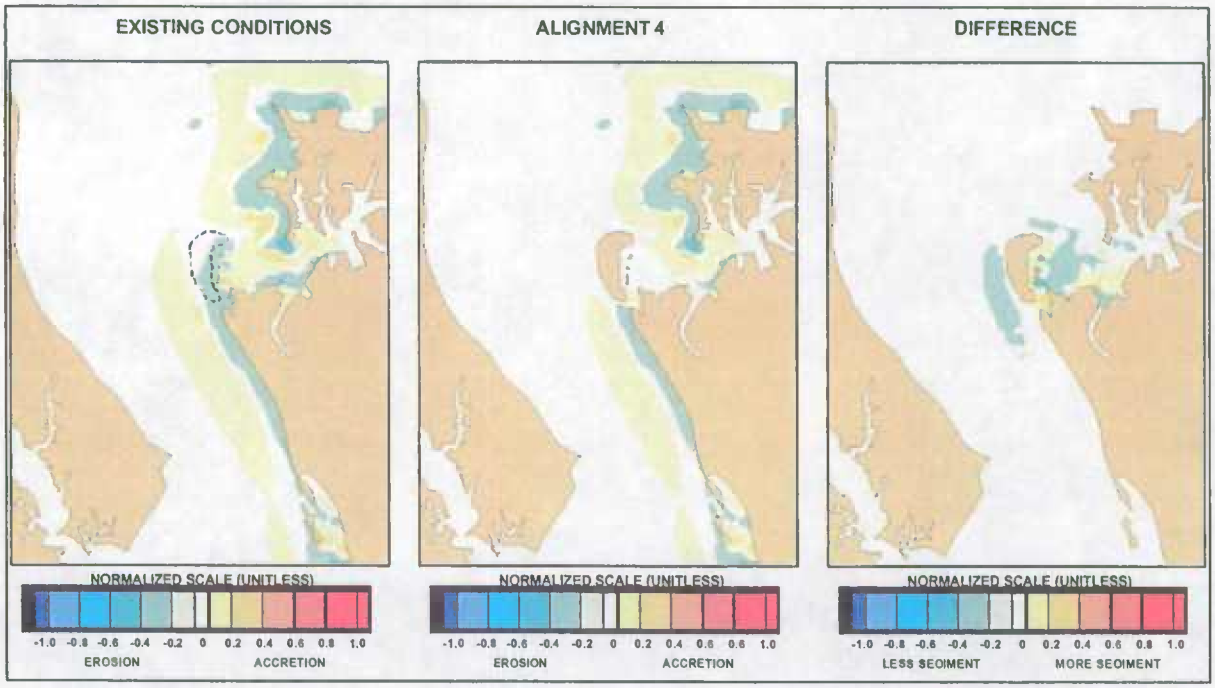


Figure 7-24: Cohesive Sediment – West-Northwest Wind 13 mph – Alignment 4 vs. Existing Conditions

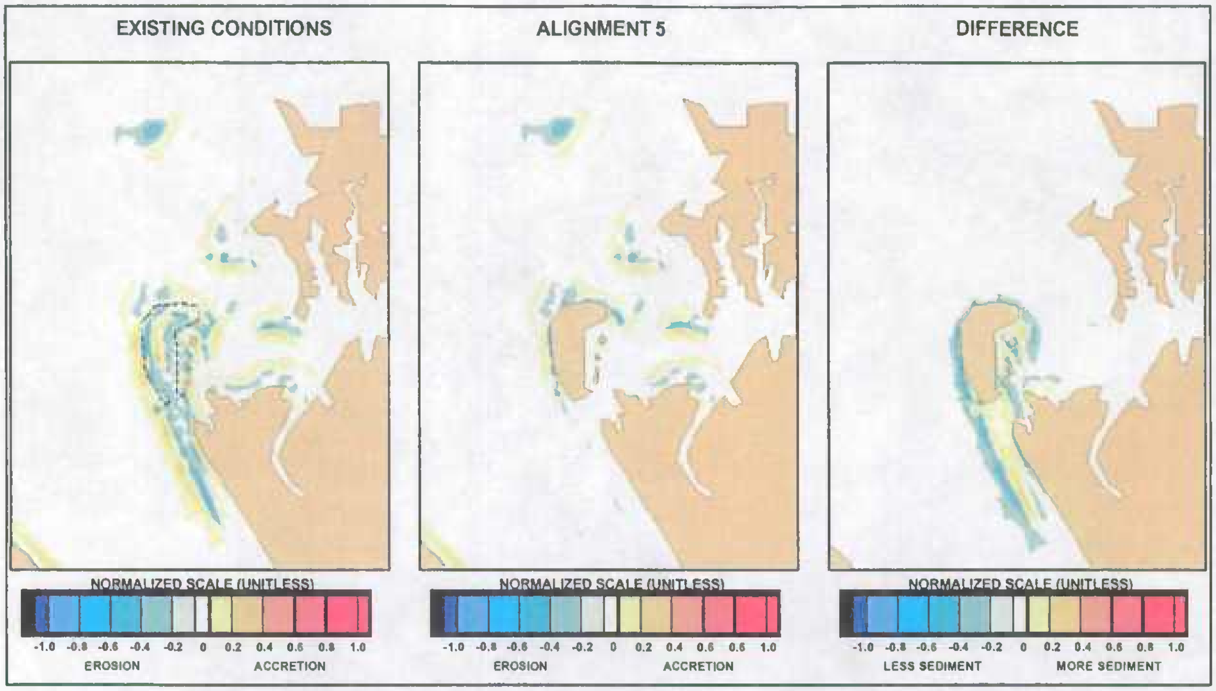


Figure 7-25: Non-Cohesive Sediment – North-Northwest Wind 16 mph – Alignment 5 vs. Existing Conditions

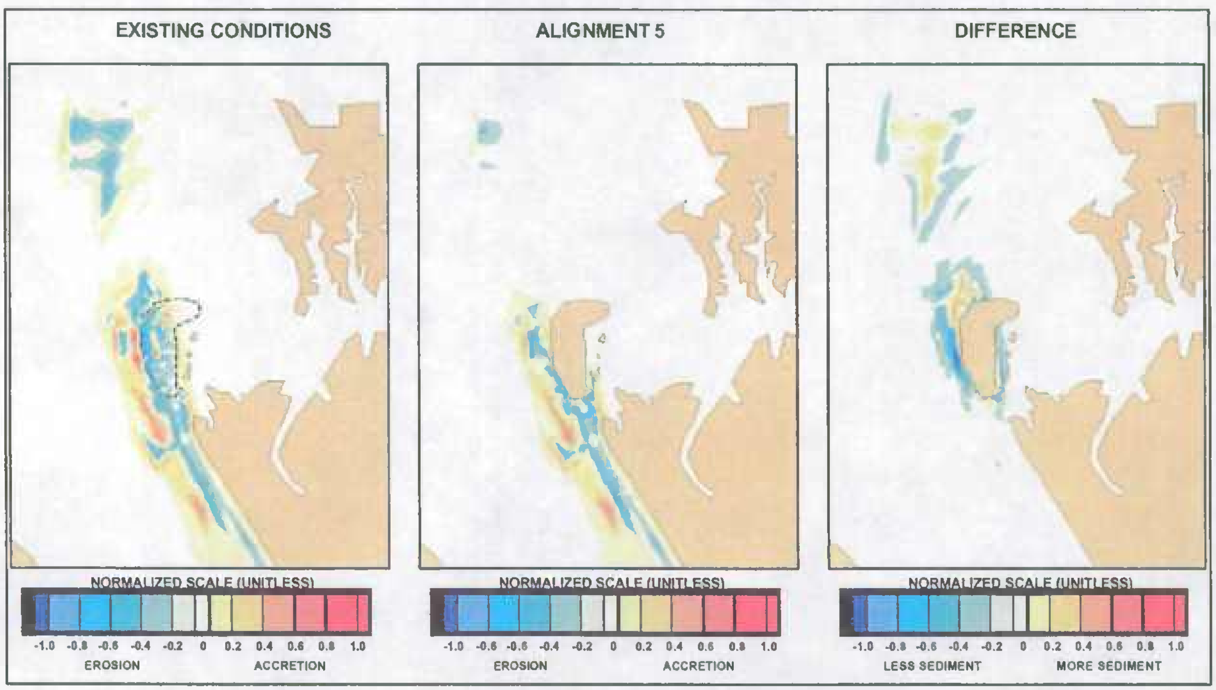


Figure 7-26: Non-Cohesive Sediment – South-Southeast Wind 16 mph – Alignment 5 vs. Existing Conditions

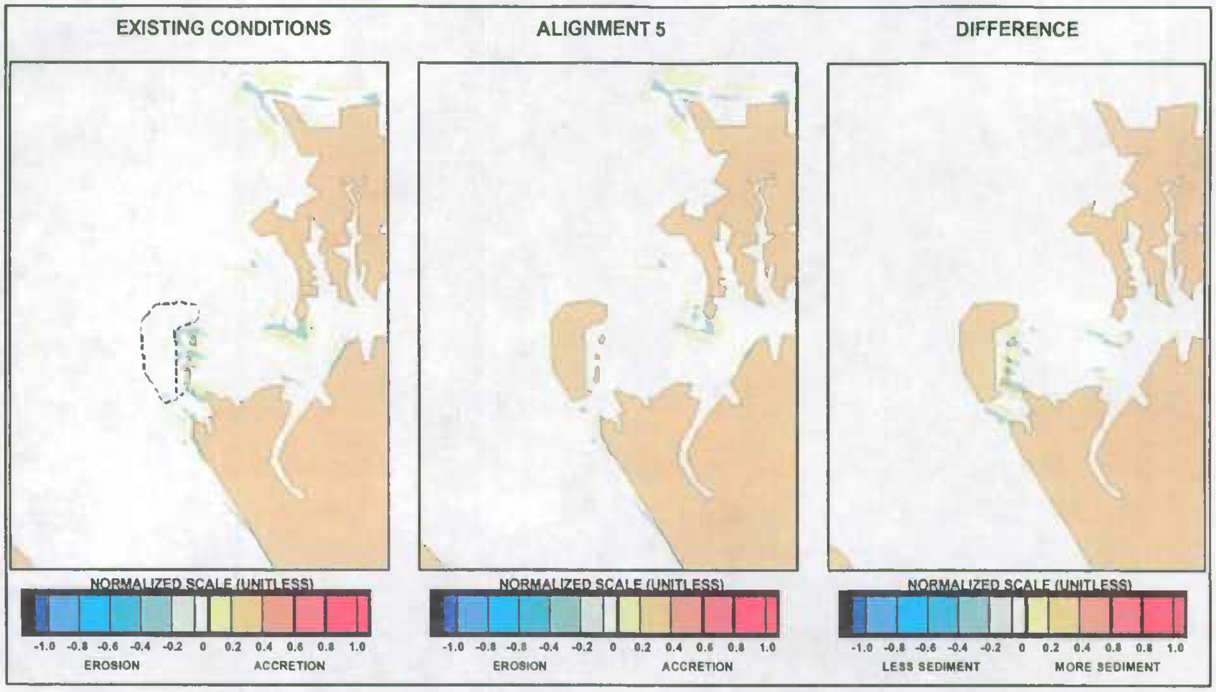


Figure 7-27: Non-Cohesive Sediment – West -Northwest Wind 16 mph – Alignment 5 vs. Existing Conditions

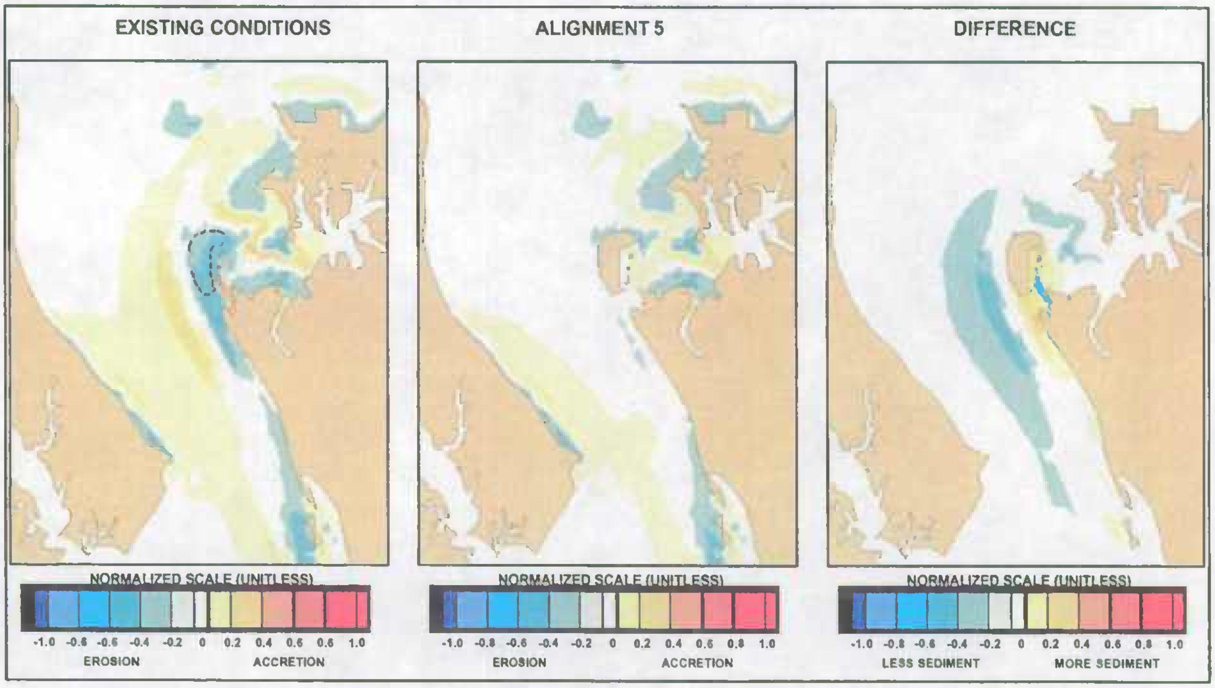


Figure 7-28: Cohesive Sediment – North-Northwest Wind 13 mph Alignment 5 vs. Existing Conditions

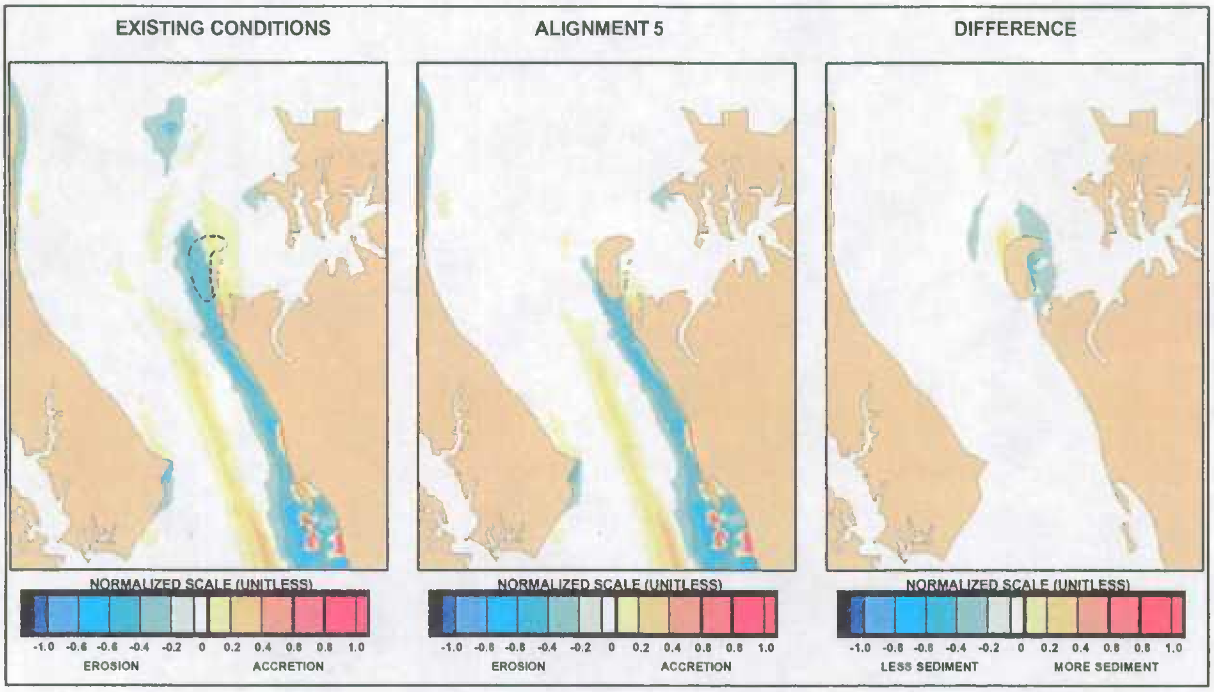


Figure 7-29: Cohesive Sediment – South-Southeast Wind 13 mph – Alignment 5 vs. Existing Conditions

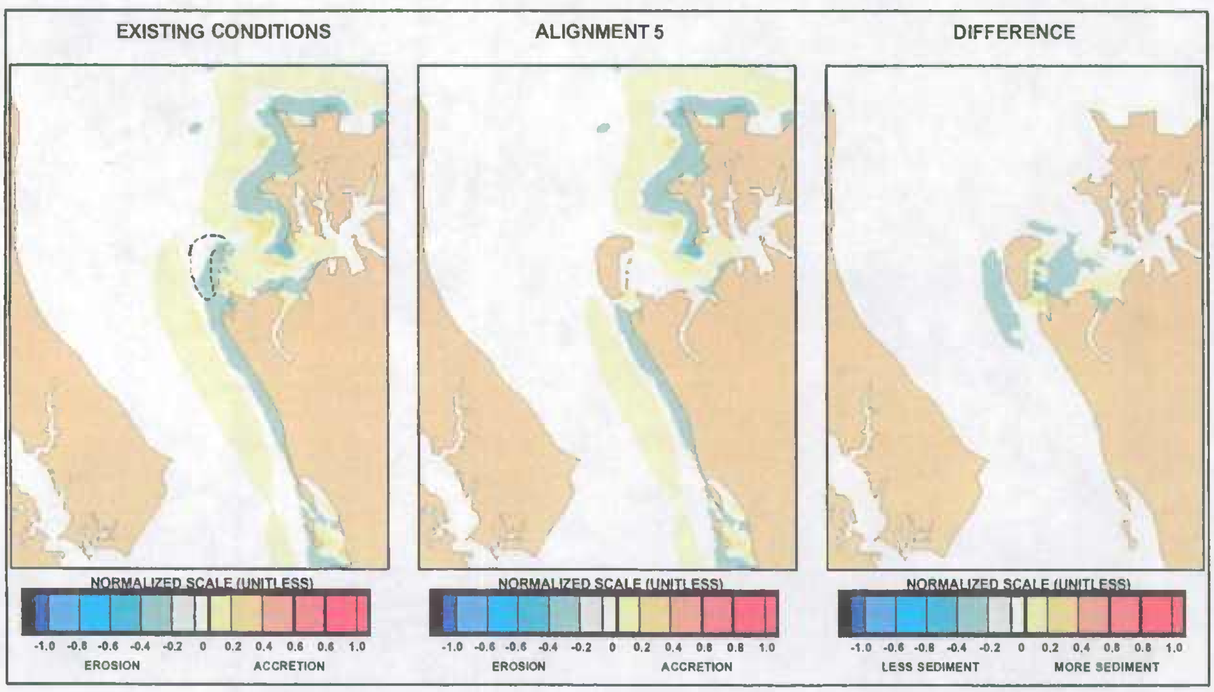


Figure 7-30: Cohesive Sediment – West-Northwest Wind 13 mph – Alignment 5 vs. Existing Conditions

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

Results of the Hydrodynamics and Sedimentation Numerical Modeling for the James Island Reconnaissance Study show that the restoration of the island would possibly impact local conditions, especially in the area east and south of the island, and negligible impacts in the far field. The primary impacts on local conditions include substantial reduction of shoreline erosion along James Island and portions of Taylors Island and improved water quality within the region due to creation of a quiescent area east of the project.

Current velocities around the north of James Island increase on the order of 0.1 to 0.2 ft/sec, current velocities east of the project decrease by 0.4 to 0.5 ft/sec, and current velocities south of the project increase by about 0.4 to 0.5 ft/sec. Negligible changes are seen in water surface elevations.

Potential changes in tidal current velocities, coupled with wind induced wave conditions, could cause changes in sedimentation patterns and rates. Non-cohesive sands exhibit reductions in both erosion and accretion rates following island creation. Cohesive clays have decreased sedimentation and decreased sediment movement east of James Island.

Note that reasonable assumptions, as regards input parameters, were made to perform this sedimentation modeling study. Because environmental conditions are constantly changing, the computed sedimentation rate will likely vary as new equilibrium conditions are reached. With this in mind, the results indicate that there will be localized changes in current velocities and sedimentation rates and patterns.

8.2 RECOMMENDATIONS

The following recommendations are made to achieve stated objectives if further evaluation and monitoring of the project area is considered.

Further numerical modeling performed using three-dimensional models would more accurately represent hydrodynamics and sedimentation in the Chesapeake Bay. A three-dimensional model would be used to simulate vertical stratification of currents and sediments due to winds and salt wedge effects. Using a three-dimensional model would allow evaluation of impacts to water quality and constituent resident times.

Additional measured data would be recommended to improve the model calibration for any further modeling studies that are considered. Data needs would include bathymetric survey, current velocity measurements, water surface elevations, and suspended sediment measurements. Water surface elevations, current velocity and sediment collection devices installed simultaneously in various locations throughout the bay and project area, and left in place for a minimum period of one month would serve to verify the model calibration. Water surface elevation and current velocities would be used to refine the hydrodynamic model; thickness of sediment and suspended sediment would be used to refine the sedimentation model.

Results obtained from the refined model could be used to examine environmental impacts including water quality as well as to optimize island alignments including fixed jetties and breakwaters.

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10. GLOSSARY OF TECHNICAL TERMS

ACCRETION. The natural or artificial buildup of land by deposition of waterborne or airborne material or by an act of man, such as the construction of a **GROIN**, **BREAKWATER**, or mechanical beach fill.

ASTRONOMICAL TIDE. The tidal levels and character which would result from gravitational effects due to the Earth, Sun, and Moon, without atmospheric influences.

BAR. A submerged or emerged embankment of sand, gravel, or other unconsolidated material built on the sea floor in shallow water by waves and currents.

BATHMETRIC CHART. A topographic map of the bed of the ocean, with depths indicated by contours (isobaths) drawn at regular intervals.

BATHYMETRY. The measurement of depths of water in oceans, seas, and lakes; also information derived from such measurements.

BAY. A recess in the shore or an inlet of a sea between two capes or headlands, not so large as a gulf but larger than a cove. See also **EMBAYMENT**.

BED LOAD. Sediment transport mode in which individual particles either roll or slide along the bed as a shallow, mobile layer a few particle diameters deep; the part of the load that is not continuously in suspension.

BED SHEAR STRESS. The transfer of energy to the sea bed from waves and currents.

BENCH MARK, TIDAL. A bench mark whose elevation has been determined with respect to **MEAN SEA LEVEL** at a nearby tide gauge; the tidal bench mark is used as reference for that tide gauge.

BOUNDARY CONDITIONS. Environmental conditions such as waves, currents, water surface elevations, etc. used as boundary input to physical or numerical models

BREAKWATER. A structure protecting a shore area, harbor, anchorage, or basin from waves.

CAUSEWAY. A raised road across wet or marshy ground, or across water.

CLAY. A fine grained, plastic, sediment with a typical grain size less than 0.004 mm. Possesses electromagnetic properties which bind the grains together to give a bulk strength or cohesion.

CORRELATION. The state or relation of being correlated; specifically: a relation existing between phenomena or things or between mathematical or statistical variables which tend to vary, be associated, or occur together in a way not expected on the basis of chance alone; a number or function that indicates the degree of correlation between two sets of data or between two random variables and that is equal to their covariance divided by the product of their standard deviations

CO-TIDAL LINES. Lines which link all the points where the tide is at the same stage (or **PHASE**) of its cycle.

COHESIVE SEDIMENT. Sediment containing a significant proportion of clays, the electromagnetic properties of which cause the sediment to bind together

CONSOLIDATION. The gradual, slow compression of a cohesive soil due to weight acting on it, which occurs as water is driven out of the voids in the soil. Consolidation only occurs in clays or other soils of low permeability.

CORIOLIS EFFECT. Force due to the Earth's rotation, capable of generating currents. It causes moving bodies to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. The "force" is proportional to the speed and latitude of the moving object. It is zero at the equator and maximum at the poles.

CURRENT. The flowing of water, or other liquid or gas or that portion of a stream of water which is moving with a velocity much greater than the average or in which the progress of the water is principally concentrated. Ocean currents can be classified in a number of different ways. Some important types include the following: (1) Periodic - due to the effect of the tides. Such Currents may be rotating rather than having a simple back and forth motion. The currents accompanying tides are known as tidal currents; (2) Temporary - due to seasonal winds. (3) Permanent or ocean - constitute a part of the general ocean circulation. (4) Nearshore - caused principally by waves breaking along a shore.

CURRENT, EBB. The tidal current away from shore or down a tidal stream. Usually associated with the decrease in the height of the tide.

CURRENT, FLOOD. The tidal current toward shore or up a tidal stream. Usually associated with the increase in the height of the tide.

CURRENT, TIDAL. The alternating horizontal movement of water associated with the rise and fall of the tide caused by the astronomical tide-producing forces. See also **CURRENT, FLOOD** and **CURRENT, EBB**.

DATUM. Any permanent line, plane or surface used as a reference datum to which elevations are referred.

DATUM, PLANE. The horizontal plane to which soundings, ground elevations, or water surface elevations are referred. The plane is called a **TIDAL DATUM** when defined by a certain phase of the tide. The following **TIDAL DATUMS** are ordinarily used on hydrographic charts:

MEAN LOW WATER - Atlantic coast (U. S.), Argentina, Sweden, and Norway.

MEAN LOWER LOW WATER - Pacific coast (U. S.).

MEAN LOW WATER SPRINGS -United Kingdom, Germany, Italy, Brazil, and Chile.

LOW WATER DATUM -Great Lakes (U. S. and Canada).

LOWEST LOW WATER SPRINGS -Portugal.

LOW WATER INDIAN SPRINGS-India and Japan (See **INDIAN TIDE PLANE**).

LOWEST LOW WATER - France, Spain, and Greece.

A common datum used on United States topographic maps is **MEAN SEA LEVEL**. See also **BENCH MARK, TIDAL**.

DEPTH. The vertical distance from a specified datum to the sea floor.

DESIGN STORM. A hypothetical extreme storm whose waves are used to design coastal protection structures. The severity of the storm (i.e. return period) is chosen in view of the acceptable level of risk of damage or failure. A design storm consists of a **DESIGN WAVE** condition, a design water level and a **DURATION**.

DESIGN WAVE. In the design of **HARBORS**, harbor works, etc., the type or types of waves selected as having the characteristics against which protection is desired.

DIFFRACTION (of water waves). The phenomenon by which energy is transmitted laterally along a wave crest. When a part of a train of waves is interrupted by a barrier, such as a **BREAKWATER**, the effect of diffraction is manifested by propagation of waves into the sheltered region within the barrier's **GEOMETRIC SHADOW**.

DIURNAL. Having a period or cycle of approximately one **TIDAL DAY**.

DIURNAL INEQUALITY. The difference in height of the two high waters or of the two low waters of each **TIDAL DAY**. Also, the difference in velocity between the two daily flood or **EBB CURRENTS** of each day.

DIURNAL TIDE. A tide with one high water and one low water in a **TIDAL DAY**.

DRAINAGE BASIN. The area drained by a stream or river and its tributaries.

DREDGING. Excavation or displacement of the bottom or shoreline of a water body with mechanical or hydraulic machines. Done to maintain channel depths or berths for navigational purposes, for shellfish harvesting, for cleanup of polluted sediments, and as a source for placement of sand on beaches.

DURATION. In wave forecasting, the length of time the wind blows in nearly the same direction over the **FETCH**.

DYNAMIC EQUILIBRIUM. Short term morphological changes that do not affect the morphology over a long period.

EBB. Period when tide level is falling; often taken to mean the ebb current which occurs during this period.

EBB CURRENT. The movement of a tidal current away from shore or down a tidal stream. The terms of maximum ebb and minimum ebb are applied to the maximum and minimum velocities of a continuously running ebb current, the velocity alternately increasing and decreasing without coming to a slack or reversing. The expression maximum ebb is also applicable to any ebb current at the time of greatest velocity.

EBB TIDE. The period of tide between high water and the succeeding low water; a falling tide.

EMBAYMENT. An indentation in the shoreline forming an open bay.

EROSION. The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

ESTUARY. (1) The part of a river that is affected by tides. (2) The region near a river mouth in which the fresh water of the river mixes with the salt water of the sea and which received both fluvial and littoral sediment influx.

FETCH LENGTH. The horizontal distance (in the direction of the wind) over which a wind generates **SEAS** or creates a **WIND SETUP**.

FETCH-LIMITED. Situation in which wave energy (or wave height) is limited by the size of the wave generation area (fetch).

FLOOD. (1) Period when tide level is rising; often taken to mean the flood current which occurs during this period (2) A flow beyond the carrying capacity of a channel.

FLOOD CURRENT. The movement of a tidal current toward the shore or up a tidal stream. The terms maximum flood and minimum flood are applied to the maximum and minimum velocities of a flood current the velocity of which alternately increases and decreases without coming to slack or reversing. The expression maximum flood is also applicable to any flood current at the time of greatest velocity.

FLOOD TIDE. The period of tide between low water and the succeeding high water; a rising tide.

FLUSHING TIME The time required to replace all the water in an **ESTUARY, HARBOR,** etc., by action of current and tide.

GROIN (British, GROYNE). Narrow, roughly shore-normal structure, built to reduce longshore currents, and/or to trap and retain littoral material. Most groins are of timber or rock. See also **T-GROIN**.

FULLY-DEVELOPED SEA. The waves that form when wind blows for a sufficient period of time across the open ocean. The waves of a fully developed sea have the maximum height possible for a given wind speed, **FETCH** and duration of wind.

GAUGE (GAGE). Instrument for measuring the water level relative to a datum.

GEOMETRIC SHADOW. In wave diffraction theory, the area outlined by drawing straight lines paralleling the direction of wave approach through the extremities of a protective structure. It differs from the actual protected area to the extent that the diffraction and refraction effects modify the wave pattern.

HINDCASTING. In wave prediction, the retrospective forecasting of waves using measured wind information.

HISTORIC EVENT ANALYSIS. Extreme analysis based on hindcasting typically ten events over a period of 100 years.

KNOT. The unit of speed used in navigation equal to 1 nautical mile (6,076.115 ft or 1,852 m) per hour.

LEE. (1) Shelter, or the part or side sheltered or turned away from the wind or waves. (2)

(Chiefly nautical) The quarter or region toward which the wind blows.

LUNAR DAY. See **TIDAL DAY.**

MEAN HIGH WATER (MHW). The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

MEAN HIGHER HIGH WATER (MHHW). The average height of the higher high waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value.

MEAN LOW WATER (MLW). The average height of the low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All low water heights are included in the average where the type of tide is either semidiurnal or mixed. Only lower low water heights are included in the average where the type of tide is diurnal. So determined, mean low water in the latter case is the same as mean lower low water.

MEAN LOWER LOW WATER (MLLW). The average height of the lower low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. Frequently abbreviated to **LOWER LOW WATER**.

MEAN RANGE OF TIDE. The difference in height between **MEAN HIGH WATER** and **MEAN LOW WATER**.

MEAN SEA LEVEL. The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings. Not necessarily equal to **MEAN TIDE LEVEL.**

MEAN TIDE LEVEL. A plane midway between **MEAN HIGH WATER** and **MEAN LOW WATER**. Not necessarily equal to **MEAN SEA LEVEL**.

NAUTICAL MILE. The length of a minute of arc, 1/21,600 of an average great circle of the Earth. Generally one minute of latitude is considered equal to one nautical mile. The accepted United States value as of 1 July 1959 is 1,852 meters (6,076.115 feet), approximately 1.15 times as long as the U.S. statute mile of 5,280 feet.

NUMERICAL MODELING. Refers to analysis of coastal processes using computational models.

PEAK PERIOD. The wave period determined by the inverse of the frequency at which the wave energy spectrum reaches its maximum.

PHASE. In surface wave motion, a point in the period to which the wave motion has advanced with respect to a given initial reference point.

SAND. Sediment particles, often largely composed of quartz, with a diameter of between 0.062 mm and 2 mm, generally classified as fine, medium, coarse or very coarse. Beach sand may sometimes be composed of organic sediments such as calcareous reef debris or shell fragments.

SCOUR. Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.

SEA GRASS. Members of marine seed plants that grow chiefly on sand or sand-mud bottom. They are most abundant in water less than 9m deep. Some common types are: Eel grass (Zostera), Turtle grass (Thallasia), and Manatee grass (Syringodium).

SEA LEVEL RISE. The long-term trend in **MEAN SEA LEVEL**.

SEAS. Waves caused by wind at the place and time of observation.

SEDIMENT. (1) Loose, fragments of rocks, minerals or organic material which are transported from their source for varying distances and deposited by air, wind, ice and water. Other sediments are precipitated from the overlying water or form chemically, in place. Sediment includes all the unconsolidated materials on the sea floor. (2) The fine grained material deposited by water or wind.

SEDIMENT TRANSPORT. The main agencies by which sedimentary materials are moved are: gravity (gravity transport); running water (rivers and streams); ice (glaciers); wind; the sea (currents). Running water and wind are the most widespread transporting agents.

SEMIDIURNAL. Having a period or cycle of approximately one-half of a tidal day (12.4 hours). The predominating type of tide throughout the world is semidiurnal, with two high waters and two low waters each tidal day. The tidal current is said to be semidiurnal when there are two flood and two ebb periods each day.

SIGNIFICANT WAVE. A statistical term relating to the one-third highest waves of a given wave group and defined by the average of their heights and periods. The composition of the higher waves depends upon the extent to which the lower waves are considered. Experience indicates that a careful observer who attempts to establish the character of the higher waves will record values which approximately fit the definition of the significant wave.

SIGNIFICANT WAVE HEIGHT. The average height of the one-third highest waves of a given wave group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period.

SILT. Sediment particles with a grain size between 0.004 mm and 0.062 mm, i.e. coarser than clay particles but finer than sand.

SPECTRAL PEAK PERIOD. PEAK PERIOD of the wave energy spectrum.

SUSPENDED LOAD. The material moving in suspension in a fluid, kept up by the upward components of the turbulent currents or by colloidal suspension.

TIDAL DAY. The time of the rotation of the Earth with respect to the Moon, or the interval between two successive upper transits of the Moon over the meridian of a place, approximately 24.84 solar hours (24 hours and 50 minutes) or 1.035 times the mean solar day. Also called **LUNAR DAY**.

TIDAL RANGE. The difference in height between consecutive high and low (or higher high and lower low) waters.

TIDE. The periodic rising and falling of the water that results from gravitational attraction of the Moon and Sun and other astronomical bodies acting upon the rotating Earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as **TIDAL CURRENT**, reserving the name **TIDE** for the vertical movement.

VISCOSITY (or internal friction). That molecular property of a fluid that enables it to support tangential stresses for a finite time and thus to resist deformation. Resistance to flow.

WAVE HEIGHT. The vertical distance between a crest and the preceding trough. See also **SIGNIFICANT WAVE HEIGHT**.

WAVE PERIOD. The time for a wave crest to traverse a distance equal to one wavelength. The time for two successive wave crests to pass a fixed point.

WIND WAVES. (1) Waves being formed and built up by the wind. (2) Loosely, any wave generated by wind.

APPENDIX D

Appendix D:

Dredging and Site Engineering

(Gahagan and Bryant Associates, Inc.)

FINAL DRAFT

JAMES ISLAND HABITAT RESTORATION PROJECT

DREDGING AND SITE ENGINEERING

RECONNAISSANCE STUDY

MPA Contract # 500912 PIN 600105P
MES Contract# 02-07-16

Prepared for:

Maryland Environmental Service
2011 Commerce Park Drive
Annapolis, MD 21401

Prepared by:

GBA

Gahagan & Bryant Associates, Inc.

Baltimore, MD

December 2002

EXECUTIVE SUMMARY

The purpose of this reconnaissance report is to summarize the dredging and site engineering aspects of restoring & developing habitat at James Island using dredged material. This study presents five dike alignments that will provide additional tidal wetland and upland habitats at James Island. The habitat restoration project would be constructed through the beneficial use of dredged materials removed from the Bay approach channels to the Port of Baltimore. The five alignments are analogous to the five alignments presented as part of the James Island Modification Conceptual Study, which was prepared for the Maryland Environmental Services (MES) in 2001. Gahagan & Bryant Associates, Inc. (GBA) has been retained by MES to conduct a reconnaissance study of the dredging and site engineering aspects of this project.

This report presents the five alignments, including: the dike design, the construction and operation, and the associated costs needed to assist decision makers in selecting the site layout to be carried to final design. The five alignments and dike cross-sections were developed based on consideration of coastal, environmental, geotechnical, dredging and site engineering aspects and data. The general location of the James Island site is shown on Figure ES-1.

For each of the five alignments, upland dike elevations of 10 ft MLLW and 20 ft MLLW were analyzed. A summary of the site design characteristics is presented in Table ES-1. A description of the site design characteristics for each option is presented below:

- *Site Surface Areas:* Site surface areas were selected minimize environmental impact and to not lie in deep waters (depths greater than –12 ft MLLW). The total site area of each option ranges between 979 and 2,202 acres. For the purposes of this study, the total surface areas are equally divided between wetland and upland habitat.
- *Total Baseline Perimeter:* The total baseline perimeter ranges between 32,102 linear feet and 48,963 linear feet for the five alignments. The total baseline is the same for both the 10 ft upland dike elevation and 20 ft upland dike elevation alternatives. This is due to the fact that the baseline is measured from the roadway on the dike crest and does not change for each alternative.
- *Neat Dike Fill Volumes:* The neat dike fill volumes for the 10 ft and 20 ft dike elevation alternatives range between 2,733,000 cy and 5,844,000 cy for the five alignments. The neat fill volumes include allowances for backfill of excavated unsuitable materials.
- *Rock Protection & Quantities:* Rock protection for the dikes was designed to yield sufficient protection against the adverse effects of high water and wave run-up resulting from a 35-year return period storm (M&N, 2002). Total rock quantities for the five alignments range between 455,000 tons and 872,000 tons. These quantities include toe armor, quarry run, slope armor, and slope underlayer stone.
- *Potential Borrow Sources & Volumes:* There are four potential sand borrow sites within the vicinity of the James Island project. Two of the sites are located north and west of James Island and two are located southeast and southwest of the Island. The northern location has a total volume of 14.2 mcy, the western location has a total volume of 1.1 mcy, the southeast

location has a total volume of 1.0 mcy, and the southwest location has a total volume of 0.3 mcy. These are total volumes. Estimated available sand volumes are presented in Figures B-7 through B-11 in Appendix B.

- ***Site Capacity & Operational Life:*** For the 10 ft. upland dike elevation alternative, the site capacity for the five alignments ranges between 23 and 52 mcy. For the 20 ft upland dike elevation alternative, the site capacity for the five alignments ranges between and 35 and 79 mcy. The site operational life is estimated to range between 13 and 15 years for the five alignments with respect to the 10 ft. dike elevation. The site operational life is estimated to range between 20 and 23 years for the five alignments with respect to the 20 ft. dike elevation.

For the purpose of this report it is assumed that the hydraulic stockpile and truck haul method of dike fill construction (the method previously used at Poplar Island) will be used. It is assumed that a small hydraulic dredge will complete excavation and backfill of the unsuitable foundation material. It is assumed that rock will be transported by barge to the site and then be handled by a crane at or near the dike section. A summary of the estimated completion time for dike construction is presented in Table ES-2. These completion times are based on the following assumptions:

- The total completion time was based on the time required for the longest construction element (rock placement for the 10 ft dike elevation and hydraulic fill for the 20 ft dike elevation) plus an additional six months to allow for mobilization, demobilization and overlap of the construction elements,
- 30 working days per month at 12 hour days,
- 15,000 cubic yards of dike material are dredged and stockpiled per day,
- 5,000 cubic yards of dike material are placed per day,
- Rock placement includes toe dike, slope stone and road stone, and
- 50 lineal feet of stone will be placed per day.

As part of development of the Island site, 50% of the island restoration area will be habitat creation, including, intertidal wetland, high marsh, low marsh, bird islands, mud flats and circulation channels.

This report assumes that, once the maintenance dredged material placed at the site approaches the elevation of the bay water level, crust management is implemented in order to maximize the operational life of the site. Also, dried crust resulting from such operations could be a valuable source for building berms and for future dike raising.

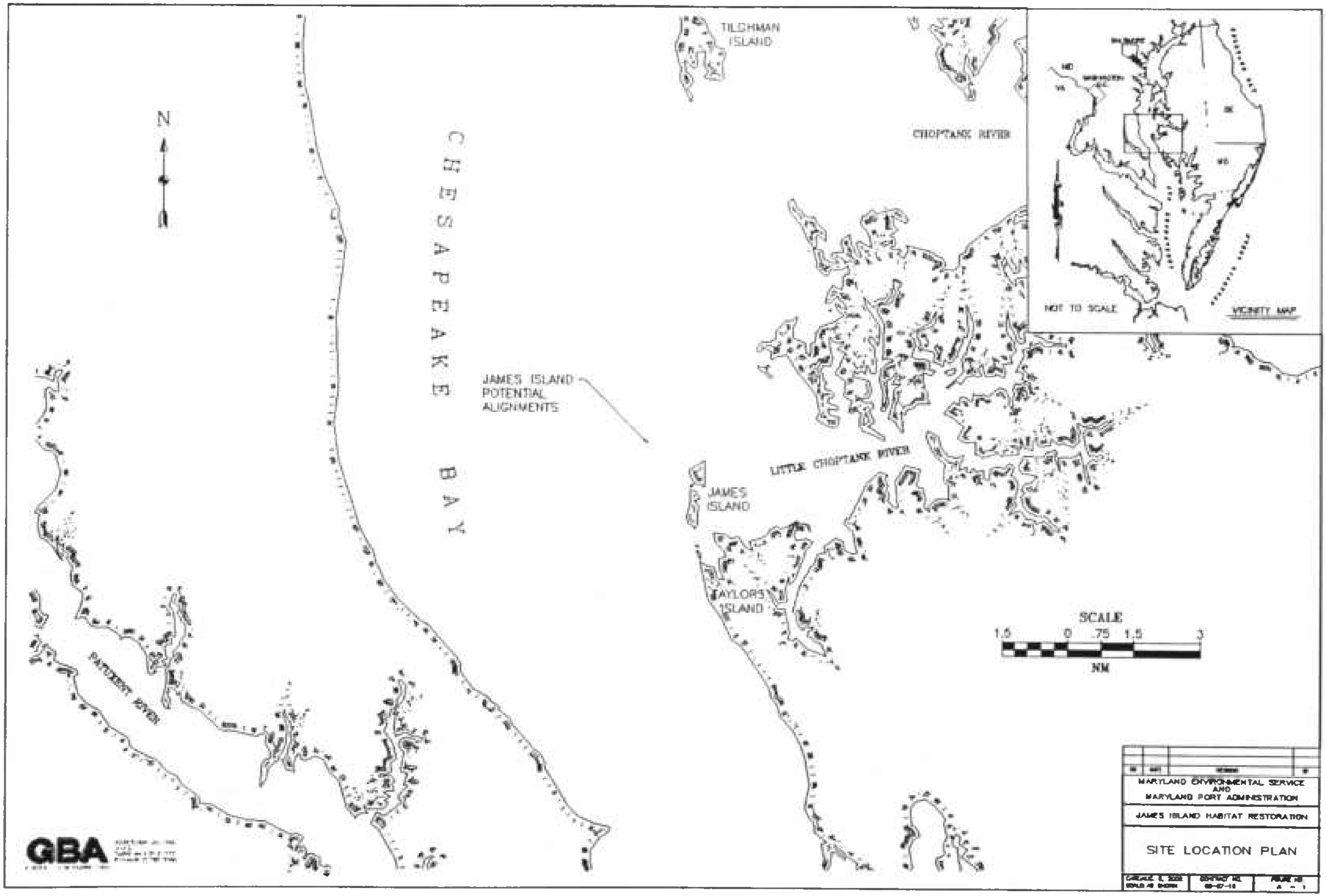

Figure ES-1, Site Location Map

Table ES-1. Site Design Characteristics and Quantities

Alignment	Total Surface Area (Acres)	Dike Perimeter Length (Lin. Ft.)	Neat Dike Fill Volume (CY)		Dike Rock Placement (Tons)	Site Capacity (Mcy)		Total Site Life (Years)	
			Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW		Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW	Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW
1	979	32,102	2,733,000	4,505,000	455,000	23	35	13	20
2	2,127	48,812	3,149,000	5,437,000	872,000	52	78	15	22
3	1,586	44,497	3,578,000	5,694,000	694,000	37	57	13	20
4	2,202	48,963	3,086,000	5,493,000	860,000	51	79	15	23
5	2,072	45,587	2,994,000	5,844,000	819,000	49	75	14	21

Table ES-2 Estimated Construction Completion Times

Alignment	Stockpile Completion Time (Days)		Dike Fill Completion Time (Days)		Dike Rock Placement (Tons)	Rock Placement Time (Days)	Total Completion Time (Years)	
	Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW	Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW			Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW
1	182	300	547	901	455,000	642	2.3	3.0
2	210	362	630	1,087	872,000	976	3.2	3.5
3	239	380	716	1,139	694,000	890	3.0	3.7
4	206	366	617	1,099	860,000	979	3.2	3.6
5	200	390	599	1,169	819,000	912	3.0	3.7

The total project costs, in constant 2002 dollars, for the operational life of the facility were generated as the sum of the initial construction costs, habitat development costs, site development costs, and the dredging, transport and placement costs. Table ES-3 presents the costs related to the 10 ft. upland dike elevation alternative, and the costs related to the 20 ft upland dike elevation alternative. The total project costs are the summation of all the above referenced costs. These costs, along with the cost per cubic yard of capacity for the site, are presented to compare the five island alignments.

Table ES-3 Summary of Site Costs

Alignment	Total Site Capacity (Mcy)	Total Site Life (Yrs.)	Project Costs ($ Millions)			Cost per CY Capacity ($/CY)
			Apportioned to		Total Project Costs	
			James Island	Channel Projects		
10 Ft. MLLW Dike Elevation:						
1	23	13	308	99	406	18
2	52	15	531	227	759	15
3	37	13	430	164	594	16
4	51	15	526	225	751	15
5	49	14	494	214	709	14
20 Ft. MLLW Dike Elevation:						
1	35	20	439	152	591	17
2	78	22	759	342	1,101	14
3	57	20	611	250	861	15
4	79	23	762	344	1,106	14
5	75	21	724	326	1,050	14

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APPENDICES

1.0 INTRODUCTION

1.1 PROJECT OBJECTIVE

The objective of this study was to conduct a Dredging Engineering Reconnaissance Study for the construction of James Island Habitat Restoration Project. This study presents various alignments for the restoration of this site to rebuild James Island to its 1847 historic footprint, utilizing dredged material to accomplish the restoration. Gahagan & Bryant Associates, Inc. (GBA) tasks include:

Task 1 – Review Existing Data – Conduct a review of the existing information on site characteristics and information related to a potential beneficial use habitat restoration site at James Island.

Task 2 – Base Mapping – Develop base mapping with digital bathymetric information using NOAA charts, including all pertinent information available from the Maryland Department of the Environment (MDE), Maryland Department of Natural Resources (MDNR), Maryland Geological Survey (MGS), Maryland Environmental Service (MES), U.S. Army Corps of Engineers (USACE) and Maryland Port Administration (MPA).

Task 3 – Preliminary Site Layout and Design – Prepare preliminary site configurations and dike alignments consistent with available subsurface geological data obtained from the Geotechnical Pre-Feasibility Study for James Island (E2CR, 2002). The site configuration and dike alignments shall be consistent with the historic mid-1800s island footprint and where available shall maximize existing shallow areas. The beneficial use and habitat restoration project at James Island should be similar in general concept to the Poplar Island Habitat Restoration Project with a wetland to upland ratio suitable for the project and filling capacity for 40 to 80 million cubic yards of dredged sediment.

Based on the preliminary site layout and conceptual design, GBA shall provide analyses of site filling capacity, dredged material transportation feasibility, and borrow source identification. As part of this task, GBA shall prepare plan sheets showing site layout(s) and typical construction details and conceptual design elements including but not limited to dike geometry and fill volumes, site volumes and capacities, spillways and site facilities, and site construction methods (including site access).

Task 4 – Reconnaissance Cost Estimates – Based on the preliminary site layout and conceptual design, GBA will prepare a comprehensive site use cost estimate with supporting details on assumptions used for the cost estimate. The cost estimate shall include:

- Study costs
- Initial construction costs
- Construction management costs
- Operation and maintenance costs (annual and total)
- Unloading costs

- Monitoring costs
- Dredging and transportation costs
- Design costs
- Site Finish costs
- Total costs
- Unit costs

1.2 PROJECT HISTORY AND DESCRIPTION

The U.S. Army Corps of Engineers, Baltimore District (CENAB) maintains more than 125 miles of federal navigation channels providing access to the Port of Baltimore. Placement of the material removed during maintenance dredging of these channels requires substantial planning and commitment of resources. Beneficial use of dredged material is an important option, providing opportunities for environmental enhancement while also providing for the necessary ongoing activity of port maintenance.

James Island is a privately owned island located in Dorchester County, MD on the eastern shore of the Chesapeake Bay at the mouth of the Little Choptank River. James Island is located 15 nautical miles south of the Poplar Island Habitat Restoration Project. James Island was approximately 974 acres in 1847; by 1994 approximately 92 acres remained. Since 1847 an estimated 78% of James Island has been lost to erosion with most of the erosion occurring on the west side of the island at a rate of 6 acres per year (E2CR, 2002).

1.3 PROJECT SCOPE & ORGANIZATION

The scope of this project was to conduct a reconnaissance study of the James Island site for the Port of Baltimore. In order to conduct the reconnaissance study, the Maryland Port Administration (MPA) retained four consultants to study the following aspects:

EA Engineering, Science & Tech., Inc. (EA)	Environmental Investigations
Engineering, Consultation, Construction, Remediation (E2CR)	Geotechnical Investigations
Gahagan & Bryant Associates, Inc. (GBA)	Dredging & Site Engineering Investigation
Moffatt & Nichol Engineers (M&N)	Coastal Engineering Investigation

The Maryland Environmental Service (MES) managed inter-organization as well as technical and advisory support for the reconnaissance study at the request of MPA. Technical support was provided by Maryland Department of the Environment (MDE), and the Maryland Geological Survey (MGS).

The results of the study were to be summarized as follows: (i) individual technical report by each of the consultants, (ii) a legislative report providing an executive summary of the four reports to be provided to the Maryland State Legislature, and (iii) a consolidated report summarizing the key aspects of the four study reports. This report outlines the results of the dredging & site engineering investigation conducted by GBA.

2.0 BASE MAPPING

2.1 GENERAL

James Island is a privately owned island located in Dorchester County, MD on the eastern shore of the Chesapeake Bay at the mouth of the Little Choptank River. James Island is 47 miles southeast of Baltimore Washington International Airport (Figure 1, Appendix A).

2.2 GEOTECHNICAL RECONNAISSANCE MAP

Geotechnical Reconnaissance Maps have been generated for the five alignments. Figures B-1 through B-5 in Appendix B show the geotechnical reconnaissance with respect to each alignment. The bathymetric data used to generate the maps was obtained from NOAA charts 12266 and 12264. Boring locations, vane shear locations, and electronic cone penetrometer test locations are presented on the maps. The location and data results were provided by E2CR (E2CR, 2002).

The locations of the Natural Oyster Bars (NOB) are also presented on the geotechnical reconnaissance maps. Each option is sited to avoid impacts to the NOB areas. The data used to identify the NOB areas was digitized from base maps prepared by the Coast and Geodetic Survey for the Department of Natural Resources, (State of Maryland, 1961).

2.3 SAND BORROW AREA MAPS

The general location of the potential sand borrow areas are presented in Figure B-6 of Appendix B. Based on the preliminary geotechnical results there is adequate sand to construct the project. There are four potential sand borrow sites within the vicinity of the James Island Habitat Restoration project. Two of the sites are located north and west of James Island and two are located southeast and southwest of the Island. Figures B-7 through B-11 present the location and quantities of available sand (less the footprint) for each option. The data used to generate the Sand Borrow Area maps was referenced from the Geotechnical Reconnaissance Study for James Island (E2CR 2002).

3.0 SITE LAYOUT

3.1 SITE LAYOUT ALIGNMENT 1

The Alignment 1 site layout, depicted in Figure 3-1, is the smallest layout with a boundary of James Island to the east. The upland portion is on the western side and the wetland portion is on the eastern side of James Island Habitat Restoration Project. Details of the Option 1 layout can be obtained from Figure C-1 in Appendix C. The total site is approximately 979 acres.

3.2 SITE LAYOUT ALIGNMENT 2

The Alignment 2 site layout, depicted in Figure 3-1, has a boundary of James Island to the east, deep water to the west, NOB to the north and a local navigation channel to the south. The upland portion is on the western side and the wetland portion is on the eastern side of James Island Habitat Restoration Project. Details of the Option 2 layout can be obtained from Figure C-2 in Appendix C. The total site is approximately 2,127 acres

3.3 SITE LAYOUT ALIGNMENT 3

The Option 3 site layout, depicted in Figure 3-1, is a variation to option 2 that has a boundary of James Island to the east, NOB to the north and Taylors Island to the south. The upland portion is on the western side and the wetland portion is on the eastern side of James Island Habitat Restoration Project. Details of the Option 3 layout can be obtained from Figure C-3 in Appendix C. The total site is approximately 1,586 acres.

3.4 SITE LAYOUT ALIGNMENT 4

The Option 4 site layout, depicted in Figure 3-1, is the largest layout and a variation to option 2 that has a boundary of James Island to the east, deep water to the west, NOB to the north and connects to Taylors Island to the south. The upland portion is on the western side and the wetland portion is on the eastern side of James Island Habitat Restoration Project. Details of the Option 4 layout can be obtained from Figure C-4 in Appendix C. The total site is approximately 2,202 acres.

3.5 SITE LAYOUT ALIGNMENT 5

The Option 5 site layout, depicted in Figure 3-1, is a variation to option 4 that has a boundary of James Island to the east, deep water to the west, NOB to the north and a local navigation channel to the south. The upland portion is on the western side and the wetland portion is on the eastern side of James Island Habitat Restoration Project. Details of the Option 5 layout can be obtained from Figure C-5 in Appendix C. The total site is approximately 2,072 acres.

ALIGNMENT 1
(979 ACRES)

ALIGNMENT 2
(2,127 ACRES)

ALIGNMENT 3
(1,586 ACRES)

ALIGNMENT 4
(2,202 ACRES)

ALIGNMENT 5
(2,072 ACRES)

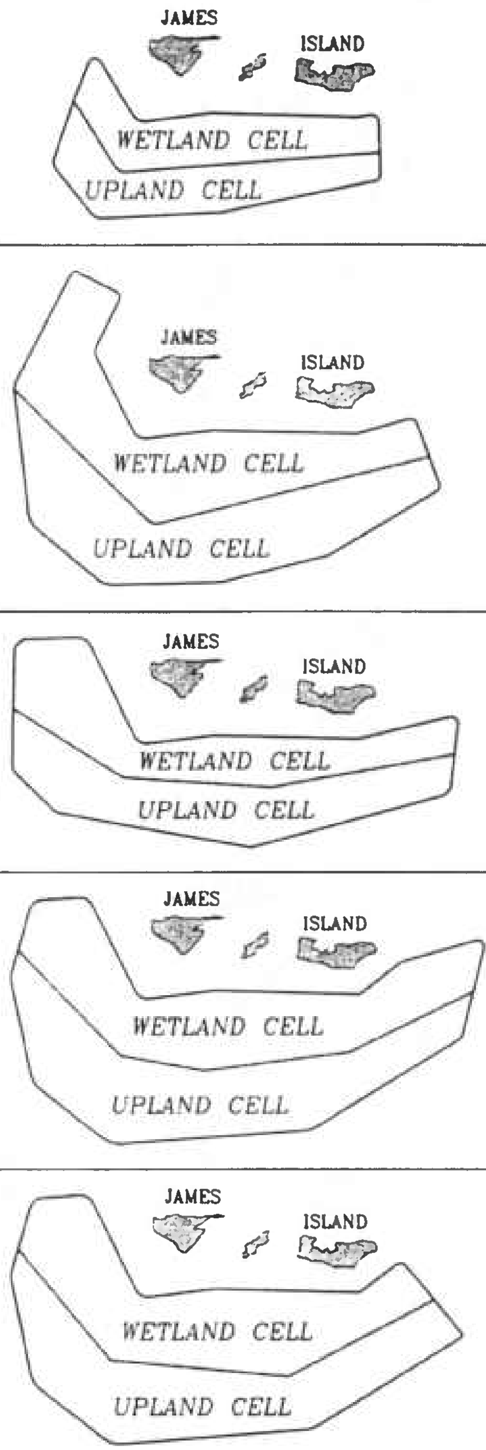


Figure 3-1 Alignment Layouts

4.0 SITE DESIGNS

4.1 GENERAL

Site design for the various alignments involved consideration of the following factors:

- *Site Surface Areas:* Site surface areas were selected to minimize environmental impact and not to lie in deep waters (i.e. waters greater than 12 ft MLLW). The total area of each option ranges between 979 and 2,202 acres. Details of the surface areas are presented in Tables D-1 through D-5 in Appendix D.

- *Dike Sections and Fill Volumes:* Upland dike elevations of +10 ft MLLW and +20 ft MLLW were analyzed for this study. Typical dike sections are presented in Drawings C-6 through C-13 (Appendix C). The neat dike fill volumes for the +10 ft MLLW and +20 ft MLLW dike elevation alternatives are presented in Table 4-1. The neat dike fills shown include allowances for backfill of excavated unsuitable material. Details of the neat dike fill volumes are presented in Tables D-1 through D-5 in Appendix D.

- *Rock Protection & Quantities:* Rock protection for the dikes was designed to provide sufficient protection against the adverse effects of high water and waves resulting from a 35-year return period storm (M&N 2002). In order to provide a high degree of protection, the armor layer was designed to a height greater than the maximum level of wave runup during storm surges. In general, the rock sections consist of a toe protection structure, geotextile filter fabric, underlayer stones, and armor stones (see Figures C-6 through C-13 in Appendix C). Where a berm was included in the dike section due to geotechnical requirements, the berm was to be used to limit wave runup and to reduce the armor size. Details of the coastal protection design can be obtained from the coastal engineering investigation reconnaissance study for James Island (M&N 2002). The required volumes of rock armor, underlayer stones, geotextile fabric, and quarry run are presented in Table 4-1. Details of the armoring quantities are presented in Tables D-1 through D-5 in Appendix D.

- *Potential Borrow Sources & Volumes:* There are four potential sand borrow sites within the vicinity of the James Island project. Figure B-6 in Appendix B shows the general location of the four borrow areas. Two of the sites are located north and west of James Island and two are located southeast and southwest of the southern end of the project site. The northern location has a total volume of 14.2 mcy, the western location has a total volume of 1.1 mcy, the southeast location has a total volume of 1.0 mcy, and the southwest location has a total available volume of 0.3 mcy. These are total volumes referenced from the Geotechnical Pre-Feasibility Study for James Island (E2CR 2002). Portions of these borrow sites are not accessible, as they are under the footprint of dikes. Estimated available sand volumes are presented in figures B-7 through B-11 in Appendix B.

- *Site Capacity & Operational Life:* The calculation of site capacity and operational life involves three primary considerations: (i) volume occupied by dredged material (accounts for material bulking during dredging, and consolidation and desiccation of dredged material following placement at the site), (ii) placement rates and lift thickness, and (iii) site area and site capacity-dike elevation relationship. For the analysis in this report, a volume occupied (VO) ratio of 0.65 was assumed above water (material placed above 0 ft MLLW) and a value of 0.75 was assumed below water (material placed below 0 ft MLLW). The calculation of the site life was determined by dividing the site capacity by the annual channel cut volume. To account for ponding and freeboard in the site capacity computations, a freeboard of 2.0 ft was provided for the upland cells. Wetland cell capacity is based on a final average elevation of +1.5. Total site capacity and operational life values for the 10 ft MLLW and 20 ft MLLW alternatives are presented in Table 4-2 at end of this section.

Table 4-1. Estimated Material Pay Quantities

Alignment	Perimeter Length (LF)	Neat Dike Fill (CY)		Quarry Run (Tons)	Under Layer (Tons)	Armor Stone (Tons)	Toe Armor (Tons)	Roadway Stone (S.Y.)	Geotextile Fabric (S.Y.)
		Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW						
1	32,102	2,733,000	4,505,000	43,000	99,000	217,000	96,000	50,000	582,000
2	48,812	3,149,000	5,437,000	106,000	173,000	393,000	200,000	74,000	882,000
3	44,497	3,578,000	5,694,000	89,000	137,000	322,000	146,000	68,000	807,000
4	48,963	3,086,000	5,493,000	110,000	170,000	382,000	198,000	75,000	888,000
5	45,587	2,994,000	5,844,000	101,000	164,000	367,000	187,000	71,000	828,000

Note: Neat dike fill includes backfill of excavated unsuitable material.

4.2 SITE DESIGN ALIGNMENTS

Five design alignments have been analyzed for the restoration of James Island. Upland dike elevations of 10 ft and 20 ft have been analyzed for this study. Site areas varied from 979 to 2,202 acres. Table 4-2 presents a summary of the planning estimates, site capacity, operational life, and neat dike fill for each alignment.

The total site capacities shown are based on a volume occupied ratio of 0.65 above water and 0.75 below water. Wetland cell capacities are based on a final average elevation of +1.5 ft MLLW. A freeboard height of 2 ft has been included for the upland cells.

Table 4-2 Site Design Alignments - Planning Estimates

Alignment	Upland Baseline Area (Acres)	Wetland Baseline Area (Acres)	Total Baseline Area (Acres)	Average Water Depth (Ft. MLLW)	Total Site Capacity (mcy)	Total Site Life (Yrs)	Neat Dike Fill (mcy)
10 Ft. MLLW Dike Elevation:							
1	489	489	979	6	23	13	2.7
2	1,063	1,063	2,127	6.5	52	15	3.1
3	793	793	1,586	6	38	13	3.6
4	1,101	1,101	2,202	6	51	15	3.1
5	1,036	1,036	2,072	6	49	14	3.0
20 Ft. MLLW Dike Elevation:							
1	489	489	979	6	35	20	4.5
2	1,063	1,063	2,127	6.5	78	22	5.4
3	793	793	1,586	6	57	20	5.7
4	1,101	1,101	2,202	6	79	23	5.5
5	1,036	1,036	2,072	6	75	21	5.8

5.0 SITE CONSTRUCTION & OPERATION

5.1 GENERAL

The significant element of construction is the containment dike system, which includes the perimeter and interior dikes. The perimeter dike consists of the dike core (mostly sand), a stone toe dike, slope stone and a stone roadway. The interior dikes consist of the dike core and a stone roadway.

The major construction elements are listed below in their order of work:

1. Borrow areas excavation
2. Placement of temporary sand stockpile
3. Excavation/Backfill of unsuitable foundation materials
4. Exterior toe dike (quarry run and armor stone)
5. Geotextile fabric placement
6. Dike (sand and silty sand, hauled from stockpile)
7. Dike armor stone (2 layers armor and under-layer)
8. Stone roadway
9. Ancillary items (spillways, a service pier, and habitat vegetation)

5.2 GENERAL SITE CONSTRUCTION

All five alignments are generally located along the west side of James Island, with portions to the north and south of the island. Fill material is assumed to be excavated from all the borrow areas, as shown on Figures B-6 through B-11 in Appendix B.

5.3 CONSTRUCTION TECHNIQUES

Dredged material containment sites may be constructed using several techniques. Construction possibilities for the fill material include direct placement using pipelines from hydraulic dredges, pump-out from hydraulic unloaders, and hydraulic stockpile trucked to the dike section. For the purpose of this report it is assumed that the hydraulic stockpile and truck haul method of dike fill construction (the method previously used at Poplar Island) will be used. It is assumed that a small hydraulic dredge will complete excavation and backfill of the unsuitable foundation material. It is assumed that rock will be transported by barge to the site and then be handled by a crane at or near the dike section.

5.4 MATERIAL PLACEMENT OPERATIONS

For dredged material placement operations, it is assumed that future maintenance materials are dredged/transported by clamshell/barge and placed within the island site by hydraulic unloader. Annual dredging volumes from Baltimore Harbor Outer Channels and the C&D Approach Channel, requiring placement at this Island site is assumed to be on average 3.5 mcy (GBA 2002). The dredging volumes include material from the following channels: (i) C&D Canal

Approach, (ii) Tolchester Channel, (iii) Swan Point Channel, (iv) Brewerton Channel Extension, (v) Craighill Upper Range Channel (including Craighill Angle, Craighill Upper Range, and Cutoff Angle Channels). Weighted average one-way transport distances were computed from these channels to the Island site based on estimated dredging quantities and the shortest distance from the centroid of the dredging locations to the site, giving due consideration of the draft requirements for the barges.

5.5 SITE OPERATIONS

As part of development of the Island site, 50% of the James Island area will be restoration and creation of wetland, including, intertidal wetland, high marsh, low marsh, bird islands, mud flats and circulation channels. The remaining 50% will be upland habitat.

This report assumes that, once the maintenance dredged material placed at the site approaches the elevation of the bay water level, crust management is implemented in order to maximize the operational life of the site. Also, dried dredged material resulting from such operations could be a valuable source for building berms and for future dike raising.

The progrcss and effectiveness of site construction and operation should be evaluated using site surveys and monitoring procedures. These typically include pre-construction environmental monitoring (contaminants, benthos, biota, etc), pre-construction surveys, quality assurance surveys, post-construction surveys, annual surveys, and post-construction environmental monitoring (ground water, TSS, effluent/runoff quality). A detailed monitoring and surveying plan (number, location, and spacing of stations and/or samples) should be developed based on site-specific factors.

General site geometries and construction quantities for the five alignments are presented in Table 5-1 for the 10 ft and 20 ft dike elevation alternatives. Table 5-1 also presents the estimated completion times for construction of the site. These completion times are based on the following assumptions:

- The total completion time was based on the time required for the longest construction element (rock placement for the 10 ft dike elevation and hydraulic fill for the 20 ft dike elevation) plus an additional six months to allow for mobilization, demobilization and overlap of the construction elements,
- 30 working days per month at 12 hour days,
- 15,000 cubic yards of dike material are dredged and stockpiled per day,
- 5,000 cubic yards of dike material are placed per day,
- Rock placcment includes toe dike, slope stone and road stone, and
- 50 lineal feet of stone will be placed per day.

Details for the costs related to construction, site development, habitat development and operation for the five alignments are discussed in Section 6 and are presented in Appendix E.

Table 5-1 Estimated Construction Completion Times

Alignment	Neat Dike Fill Volume (CY)		Stockpile Completion Time (Days)		Dike Fill Completion Time (Days)		Dike Perimeter Length (Lin. Ft.)	Dike Rock Placement (Tons)	Rock Placement Time (Days)	Total Completion Time (Years)	
	Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW	Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW	Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW				Dike Elev. 10 ft MLLW	Dike Elev. 20 ft MLLW
1	2,733,000	4,505,000	182	300	547	901	32,102	455,000	642	2.3	3.0
2	3,149,000	5,437,000	210	362	630	1,087	48,812	872,000	976	3.2	3.5
3	3,578,000	5,694,000	239	380	716	1,139	44,497	694,000	890	3.0	3.7
4	3,086,000	5,493,000	206	366	617	1,099	48,963	860,000	979	3.2	3.6
5	2,994,000	5,844,000	200	390	599	1,169	45,587	819,000	912	3.0	3.7

6.0 SITE COSTS

The total site costs for the various alignments consist of the following four major items:

- *Initial Construction Costs:* This includes construction of the dikes to the desired initial elevation, dike stabilization costs (armor, underlayer, and toe protection), installation of spillways/outlet structures, and site infrastructure. Also included in the initial construction costs are the study costs. The study costs consist of the conceptual study, reconnaissance study, and feasibility study costs.

- *Habitat Development Costs:* These are fixed and annual costs for planning, design, and implementation of wetland and upland habitat, including: circulation channels, planting and seeding, operation and maintenance (O&M), and habitat monitoring for the life of the site.

- *Site Development Costs:* This includes annual dredged material management, site maintenance, and site monitoring/reporting for the operational life of the site.

- *Dredging, Transport and Placement (DTP) Costs:* This includes costs for mobilization and demobilization, dredging the navigation channels, transport to the placement site, and unloading of the dredged material at the placement site for the operational life of the site. The DTP costs are the most significant of the four major items at about 60% of the total site costs and are further broken down and appropriated as follows:

    - *DTP Costs Appropriated to Navigation Channels:* DTP costs charged to a designated USACE navigation channel must be apportioned to that project consistent with the disposal plan identified as the Federal Standard or National Economic Development (NED) disposal plan for that project. For the purposes of this analysis we are using $3.80/cy as the estimate for the DTP costs apportioned to the USACE navigation channels. It should be noted that this NED apportionment is subject to revision and that the ongoing Dredge Material Management Plan being developed by the USACE had the potential to alter this estimate significantly.

    - *DTP Costs Apportioned to The James Island Project*: The DTP incremental costs, over and above the federal share of the NED disposal plan for that project are apportioned to the James Island Project.

Based on the above factors, the total project costs for this operational life of the site equal the sum of the initial construction, habitat development costs, site development costs, and all apportioned dredging, transport and placement costs. The total project cost, along with the cost per cubic yard of capacity, were generated to compare the various island alignments.

The cost estimates for the initial construction are developed by averaging previous bid and construction costs from the Poplar Island projects and escalating them to 2002 (See Table E-16 in Appendix E). The basis for the habitat and site development costs and the dredging , transport and placement costs are shown in Tables E-6 through E-15 in Appendix E. A 15% contingency is added to the totals of the cost estimates. It is felt that this will provide a good approximation of current day costs, suitable for these reconnaissance cost estimates and for comparing the various design alignments presented herein.

6.1 TOTAL SITE COSTS

The total project costs in constant 2002 dollars for the five alignments is presented in Table 6-1 for the 10 ft MLLW dike elevation and in Table 6-2 for the 20 ft MLLW dike elevation. The cost tables for the individual alignments are presented in Tables E-1 through E-15 (Appendix-E).

Table 6-1 Total Project Cost for 10 ft Upland Dike Elevation

	Alignment				
	1	2	3	4	5
Net Capacity (Million Cubic Yards)	23	52	37	51	49
Life (Years)	13	15	13	15	14
A. Initial Construction	66	83	85	81	78
B. Site Development	49	84	66	84	74
C. Habitat Development	24	34	28	34	32
D. Dredging, Transport and Placement	214	459	337	454	432
Subtotal $	353	660	517	653	616
Contingency @ 15%	53	99	77	98	92
Total Project Cost $	**406**	**759**	**594**	**751**	**709**
Cost per Cubic Yard Capacity $	**18**	**15**	**16**	**15**	**14**
Dredging, Transport and Placement	86	198	143	195	186
Contingency @ 15%	13	30	21	29	28
Total Channel Apportioned Cost $	**99**	**227**	**164**	**225**	**214**
Total Project Cost	406	759	594	751	709
Less Apportioned Costs to Channels	(99)	(227)	(164)	(225)	(214)
Total James Isl. Apportioned Cost $	**308**	**531**	**430**	**526**	**494**

Note: Numbers may not add up due to rounding.

Table 6-2 Total Project Cost for 20 ft Upland Dike Elevation

	Alignment				
	1	2	3	4	5
Net Capacity (Million Cubic Yards)	35	78	57	79	75
Life (Years)	20	22	20	23	21
A. Initial Construction	82	101	102	100	101
B. Site Development	73	123	97	125	113
C. Habitat Development	31	41	35	42	40
D. Dredging, Transport and Placement	328	692	514	695	660
Subtotal $	514	957	748	962	913
Contingency @ 15%	77	144	112	144	137
Total Project Cost $	**591**	**1,101**	**861**	**1,106**	**1,050**
Cost per Cubic Yard Capacity $	**17**	**14**	**15**	**14**	**14**
Dredging, Transport and Placement	132	298	217	299	284
Contingency @ 15%	20	45	33	45	43
Total Channel Apportioned Cost $	152	342	250	344	326
Total Project Cost	591	1,101	861	1,106	1,050
Less Apportioned Costs to Channels	(152)	(342)	(250)	(344)	(326)
Total James Isl. Apportioned Cost $	**439**	**759**	**611**	**762**	**724**

Note: Numbers may not add up due to rounding.

7.0 COMPARISON OF OPTION COSTS

7.1 COST-BASED ALIGNMENT COMPARISON

For a cost-based analysis of each alignment, total costs and unit costs for each alignment were considered, which included the following:

- Initial construction costs
- Habitat development costs
- Site development costs
- Dredging/transport and placement costs, and
- Contingency costs

The bascline perimeter length, total surface area, and total site capacity are important factors in estimating the costs to construct and operate the site. Unit costs are determined by dividing the total cost by the site capacity. Table 7-1 presents the site design data and associated Island project costs and unit cost for each of the five alignments with respect to the 10 ft. MLLW and the 20 ft. MLLW dike elevations. It should also be noted that alignments 1 and 3 for both the 10 ft. dike and 20 ft. dike have net annual placements less than the 3.5 mcy average requirement described in section 5.4. In the case of Alignment 1 the net annual disposal is 1.7 mcy and is 2.8 mcy for Alignment 3. All other alignments have a net annual disposal which meets the need. This explains why significant differences in project scale do not appear to cause significant changes in project life.

Table 7-1 Site Design Summary

Alignment	Baseline Perimeter Length (Ft.)	Total Surface Area (Acres)	Total Site Capacity (Mcy)	Total Site Life (Yrs.)	Project Costs ($ Millions)			Cost per CY Capacity ($/CY)
					Apportioned to		Total Project Costs	
					James Island	Channel Projects		
10 Ft. MLLW Dike Elevation:								
1	32,102	979	23	13	308	99	406	18
2	48,812	2,127	52	15	531	227	759	15
3	44,497	1,586	37	13	430	164	594	16
4	48,963	2,202	51	15	526	225	751	15
5	45,587	2,072	49	14	494	214	709	14
20 Ft. MLLW Dike Elevation:								
1	32,102	979	35	20	439	152	591	17
2	48,812	2,127	78	22	759	342	1,101	14
3	44,497	1,586	57	20	611	250	861	15
4	48,963	2,202	79	23	762	344	1,106	14
5	45,587	2,072	75	21	724	326	1,050	14

7.2 COMPARISON OF ALTERNATIVES

7.2.1 10 ft MLLW Dike Elevation

Figure 7-1 presents the total project cost versus the total surface area for each alignment with respect to the 10 ft MLLW dike elevation design alternative. Review of Figure 7-1 shows what is expected. Alignment 1 has the smallest total surface area (979 acres) and results in the lowest total cost ($406 million). Inversely, Alignment 2 has one of the largest surface areas (2,127 acres) and has a total cost of ($759 million). Alignments 2, 4 and 5 have similar surface areas, which result in similar total costs.

Figure 7-2 presents the unit cost per cubic yard of capacity versus the total surface area for each alignment with respect to the 10 ft MLLW dike elevation design alternative. Alignments 2, 4 and 5 have the smallest unit cost at $14/cy and $15/cy and Alignment 1 has the largest unit cost at $18/cy. This suggests that the unit cost is sensitive to the total site surface area and a larger surface area provides for lower total unit costs.

7.2.2 20 ft MLLW Dike Elevation

Figure 7-3 presents the total project cost versus the total surface area for each alignment with respect to the 20 ft dike elevation design alternative. Review of Figure 7-3 shows what is expected. Alignment 1 has the smallest total surface area (979 acres) and results in the lowest total cost ($591 million). Inversely, Alignment 4 has the greatest surface area (2,202 acres) and has a total cost of ($1,106 million). Alignments 2, 4 and 5 have similar surface areas, which result in similar total costs. It should be noted that the total surface area does not change as a result of an increase in dike elevation. This is due to the fact that the surface area is calculated with respect to the design baseline, which does not change.

Figure 7-4 presents the unit cost per cubic yard of capacity versus the total surface area for each alignment with respect to the 20 ft MLLW dike elevation design alternative. Alignments 2, 4 and 5 have the smallest unit cost at $14/cy and Alignment 1 has the largest unit cost at $17/cy. It is again shown from Figure 7-4 that the unit cost is sensitive to the total site capacity resulting from the site design.

Figure 7-1 Total Project Cost vs. Surface Area
(for 10 ft MLLW Dike Elevation)

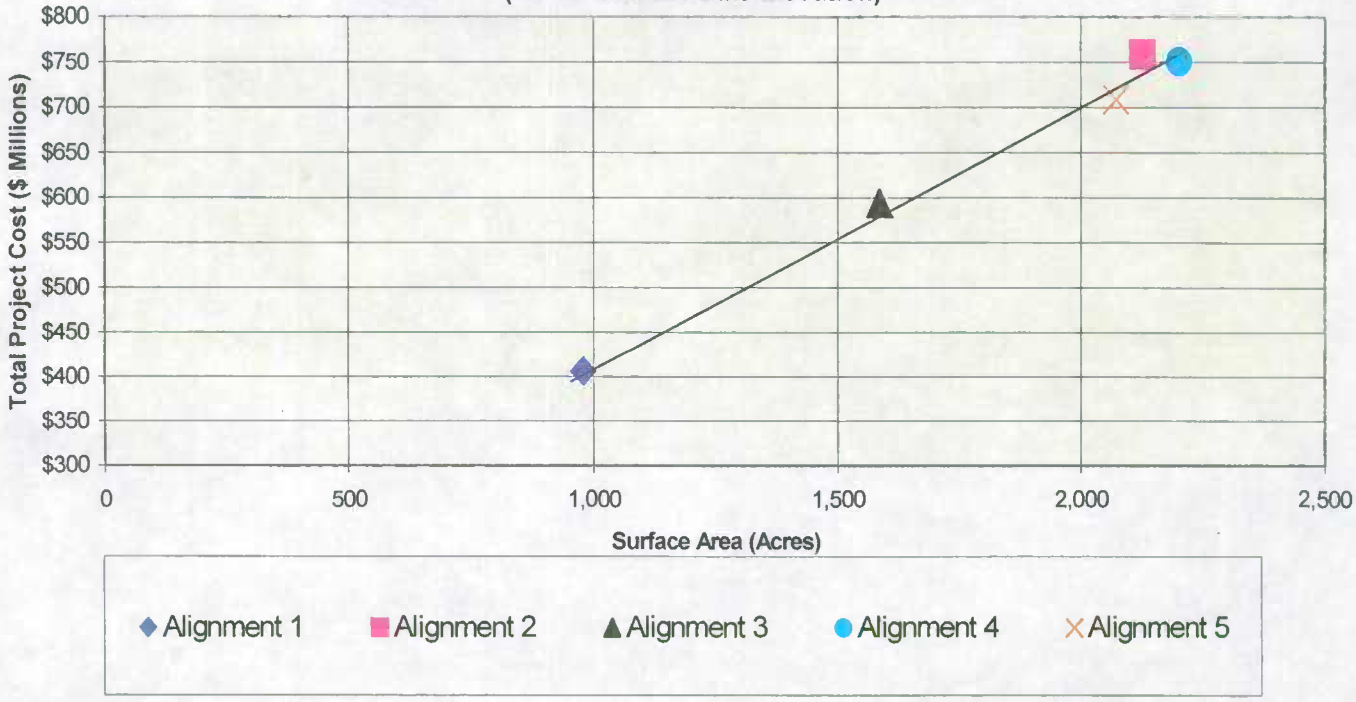


Figure 7-2 Unit Cost per CY at Capacity vs. Surface Area
(for 10 ft. MLLW Dike Elevation)

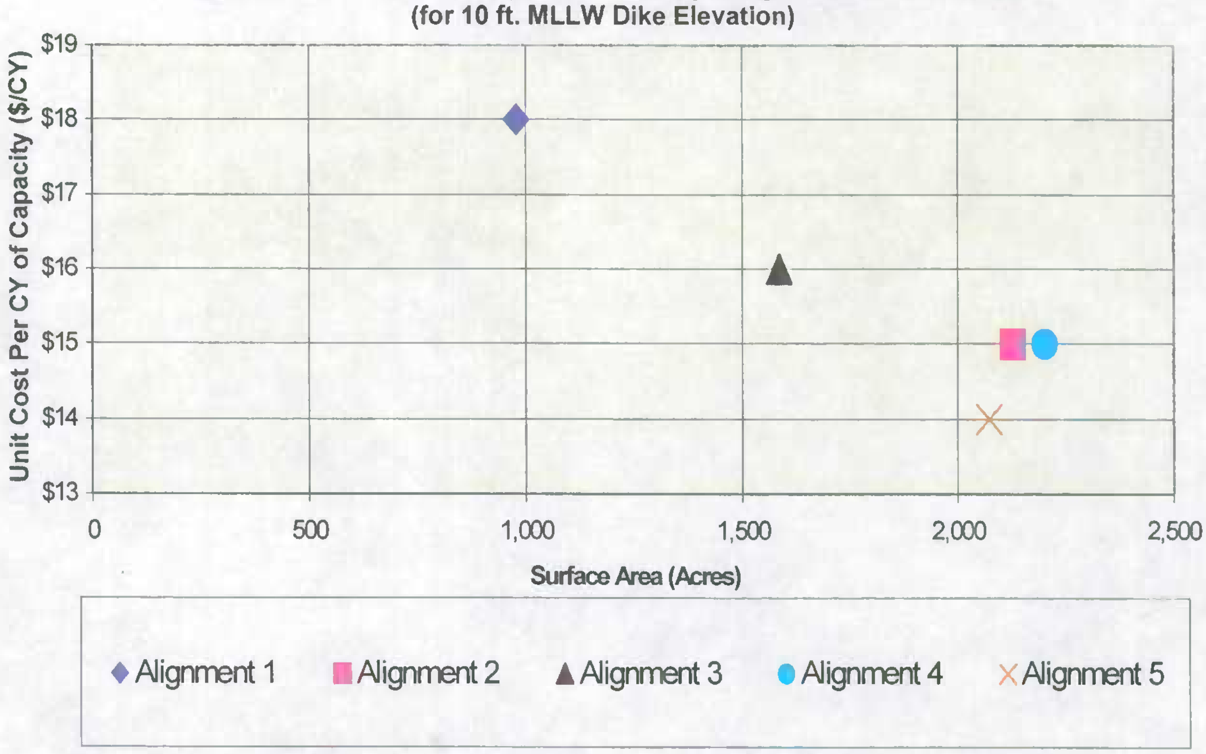


Figure 7-3 Total Project Cost vs. Surface Area
(for 20 ft MLLW Dike Elevation)

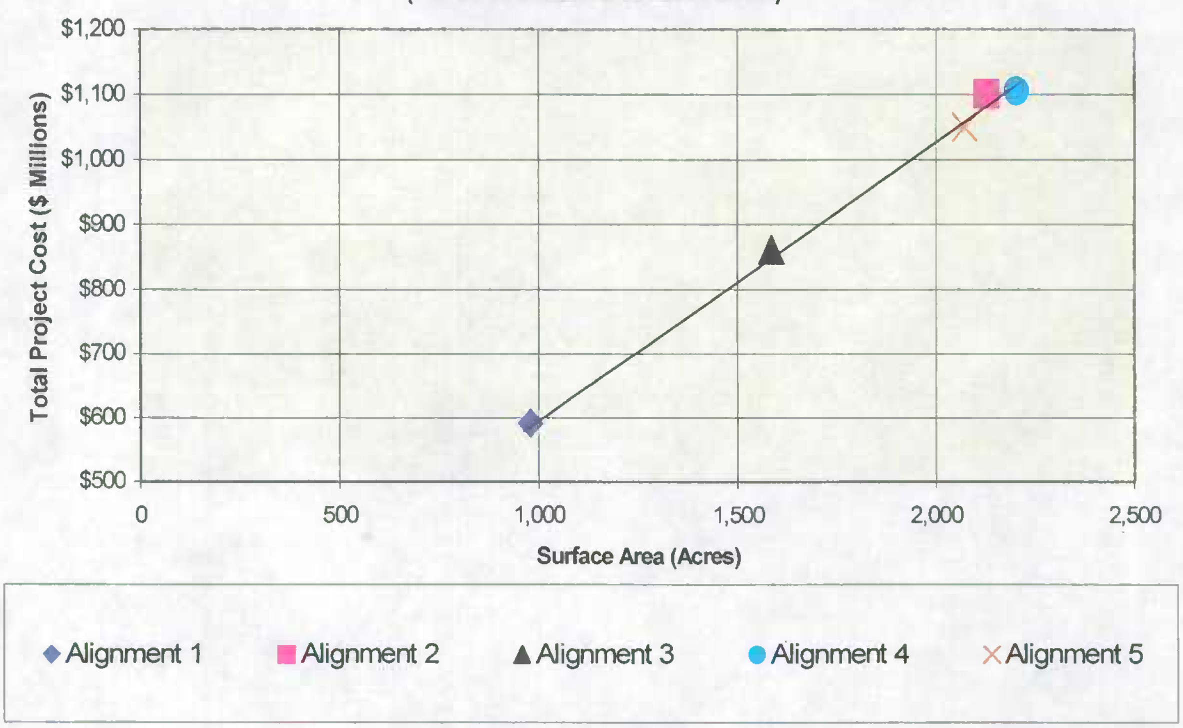
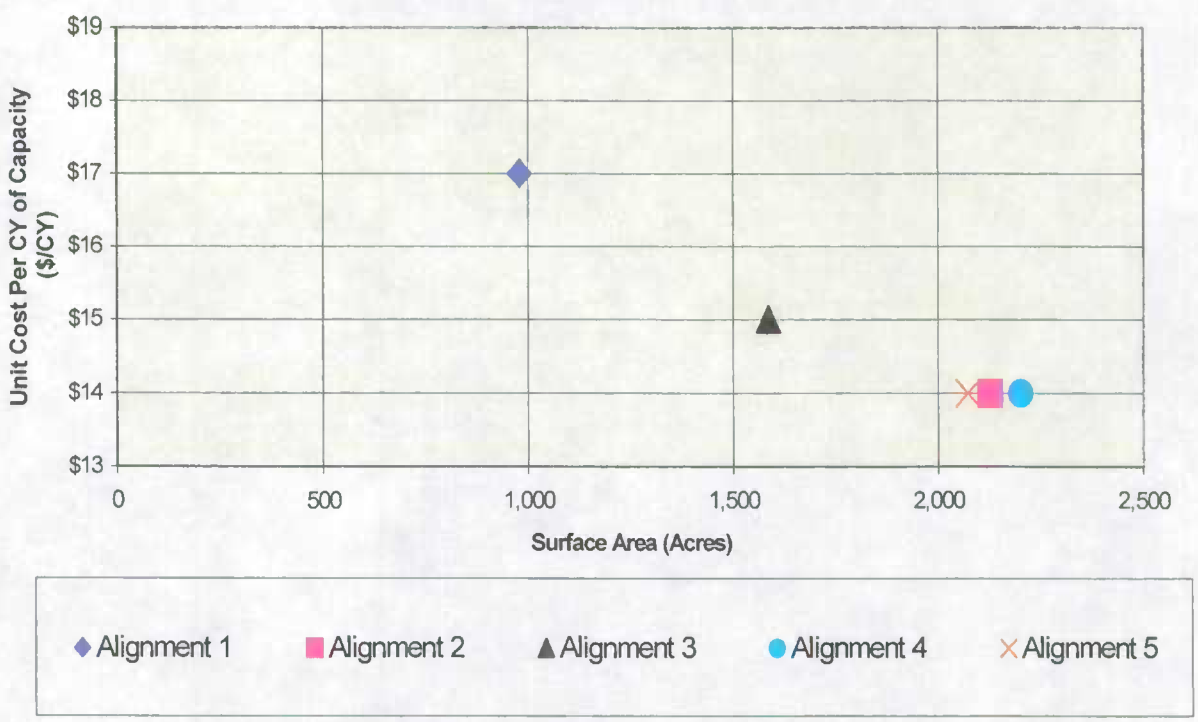


Figure 7-4 Unit Cost per CY at Capacity vs. Surface Area
(for 20 ft MLLW Dike Elevation)



8.0 REFERENCE

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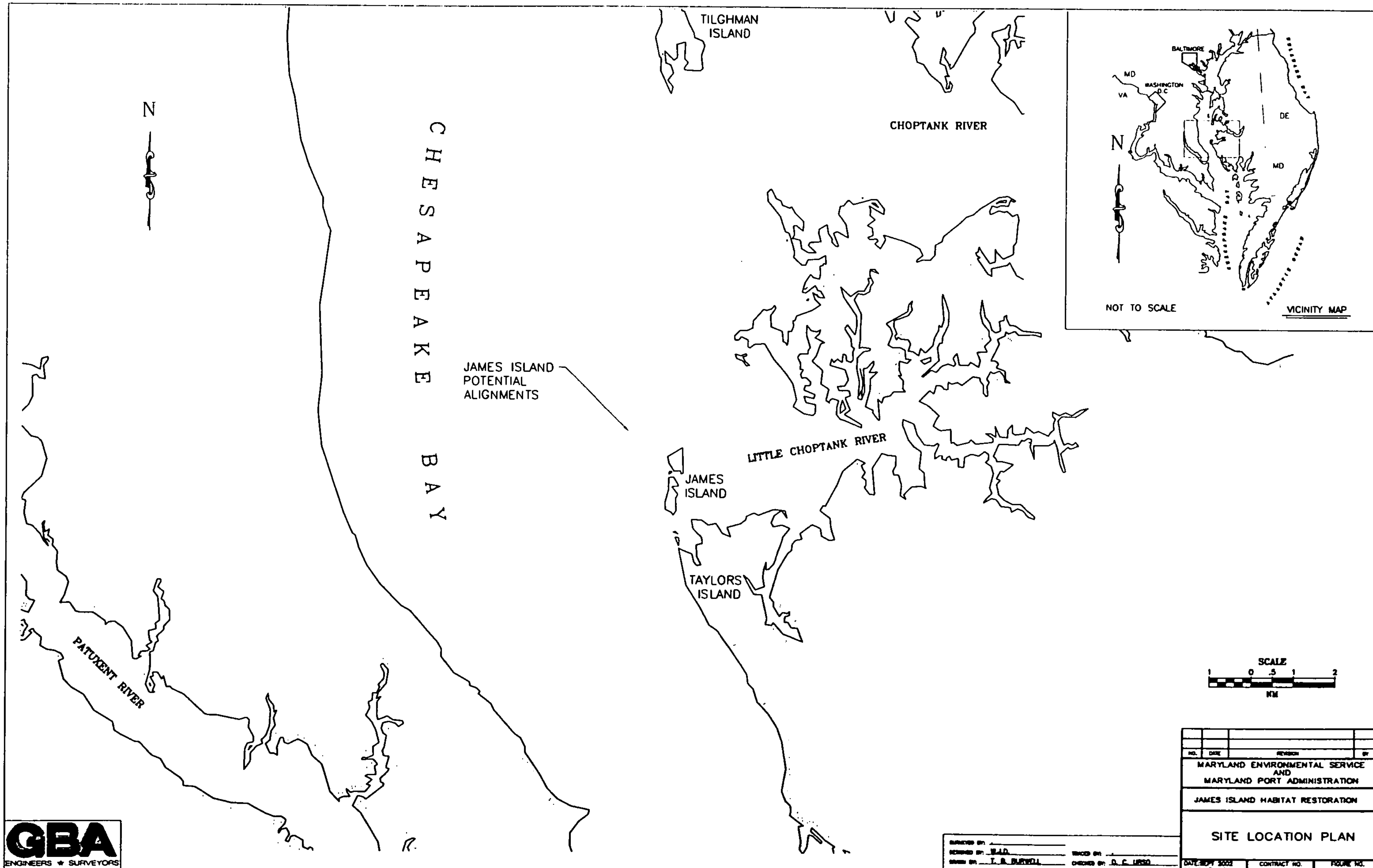
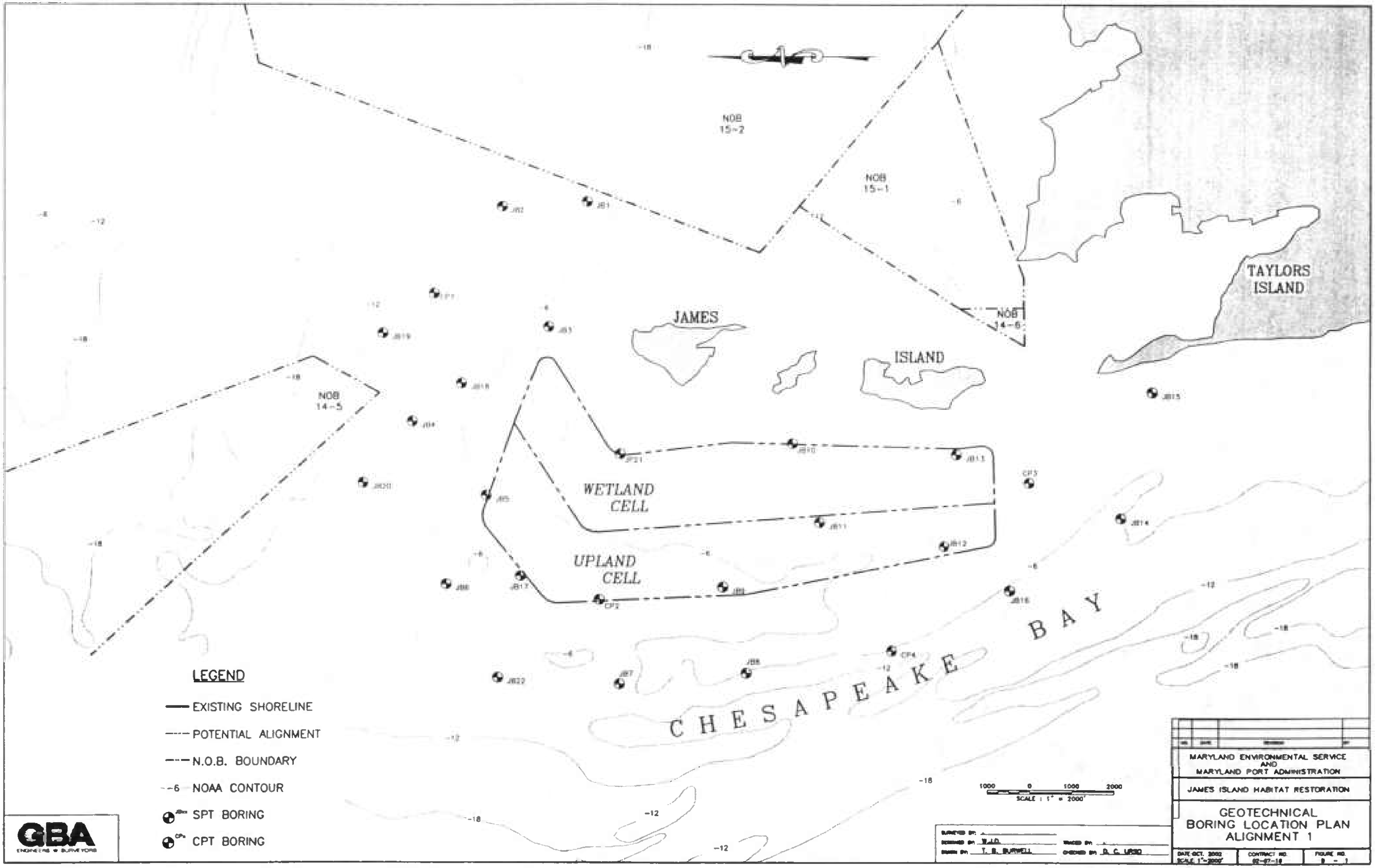
APPENDIX A

SITE LOCATION PLAN


TILGHMAN ISLAND
CHOPTANK RIVER
N
CHESAPEAKE BAY
JAMES ISLAND POTENTIAL ALIGNMENTS
LITTLE CHOPTANK RIVER
JAMES ISLAND
TAYLORS ISLAND
PATUXENT RIVER
BALTIMORE
MD
VA
WASHINGTON D.C.
DE
MD
NOT TO SCALE
VICINITY MAP
SCALE
1 0 .5 1 2
KM
MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
SITE LOCATION PLAN
T. B. BURWELL
D. C. URSO
CONTRACT NO.
FIGURE NO.
A - 1
GBA
ENGINEERS ★ SURVEYORS

APPENDIX B

GEOTECHNICAL RECONNAISSANCE MAPS
&
SAND BORROW AREA MAPS



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NOB 14-6
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JB22
CP1
CP2
CP3
CP4
JAMES
ISLAND
TAYLORS ISLAND
WETLAND CELL
UPLAND CELL
CHESAPEAKE BAY
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
N.O.B. BOUNDARY
-6 NOAA CONTOUR
SPT BORING
CPT BORING
GBA
1000 0 1000 2000
SCALE : 1" = 2000'
DESIGNED BY: W.J.O.
DRAWN BY: T. B. BURWELL
CHECKED BY: D. C. URSO
MARYLAND ENVIRONMENTAL SERVICE AND MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
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DATE OCT. 2002
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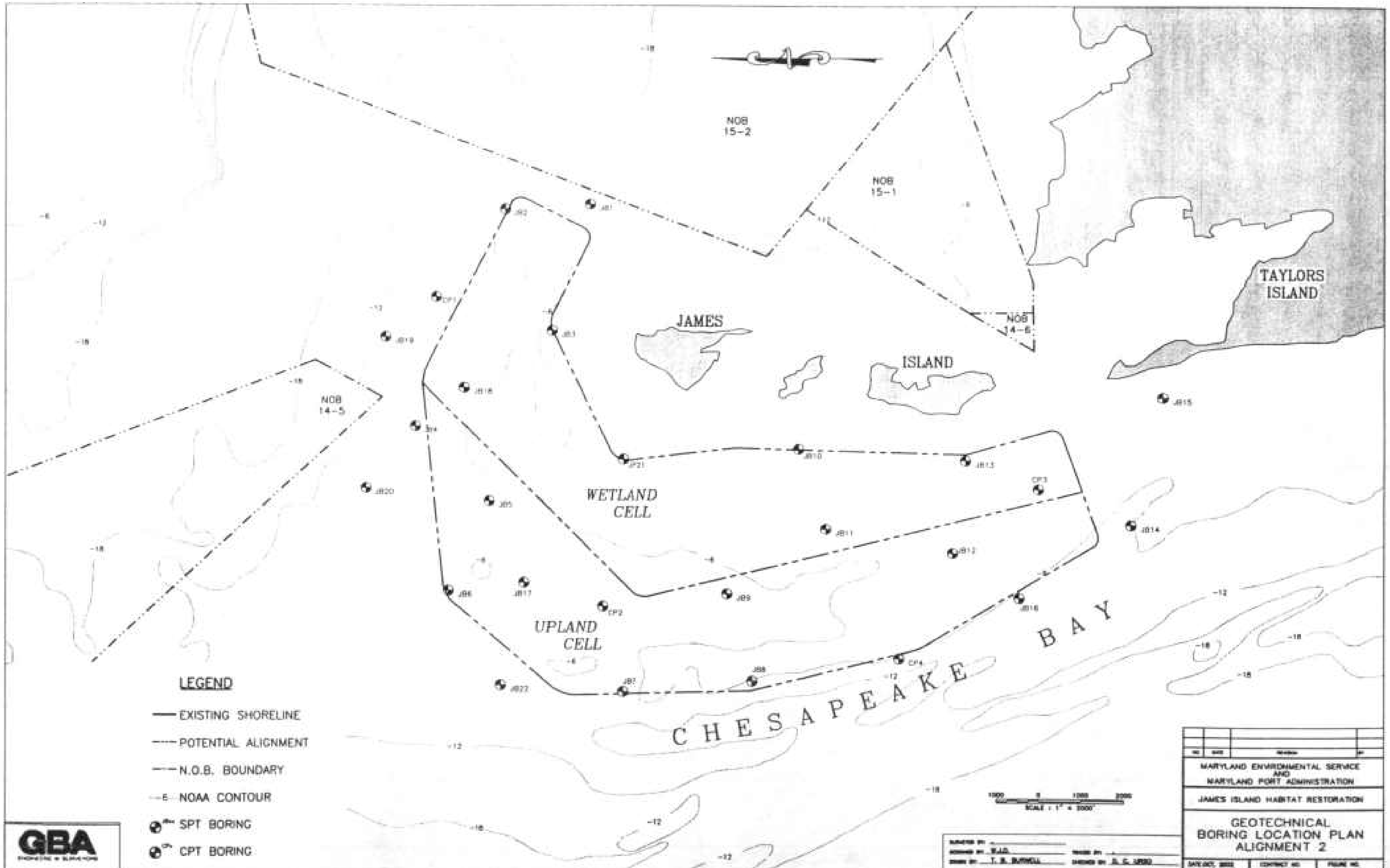
FIGURE NO. B - 1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NOB 15-1
NOB 14-6
NOB 14-5
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ISLAND
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WETLAND CELL
UPLAND CELL
CHESAPEAKE BAY
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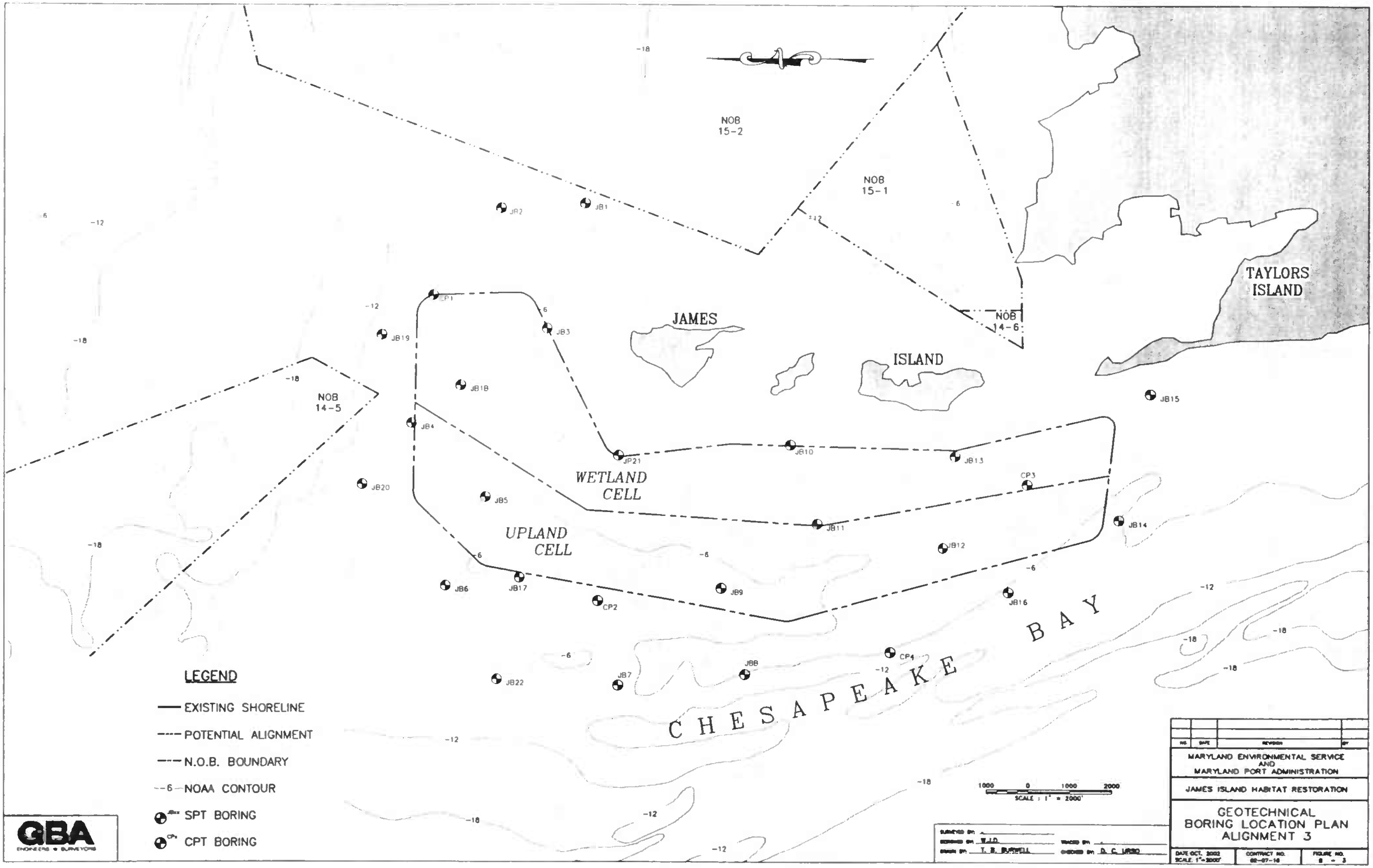
-18
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
N.O.B. BOUNDARY
NOAA CONTOUR
SPT BORING
CPT BORING
GBA
MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
GEOTECHNICAL
BORING LOCATION PLAN
ALIGNMENT 2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GBA
ENGINEERS • SURVEYORS
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SCALE : 1" = 2000'
MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
GEOTECHNICAL
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ALIGNMENT 3
DATE OCT. 2002
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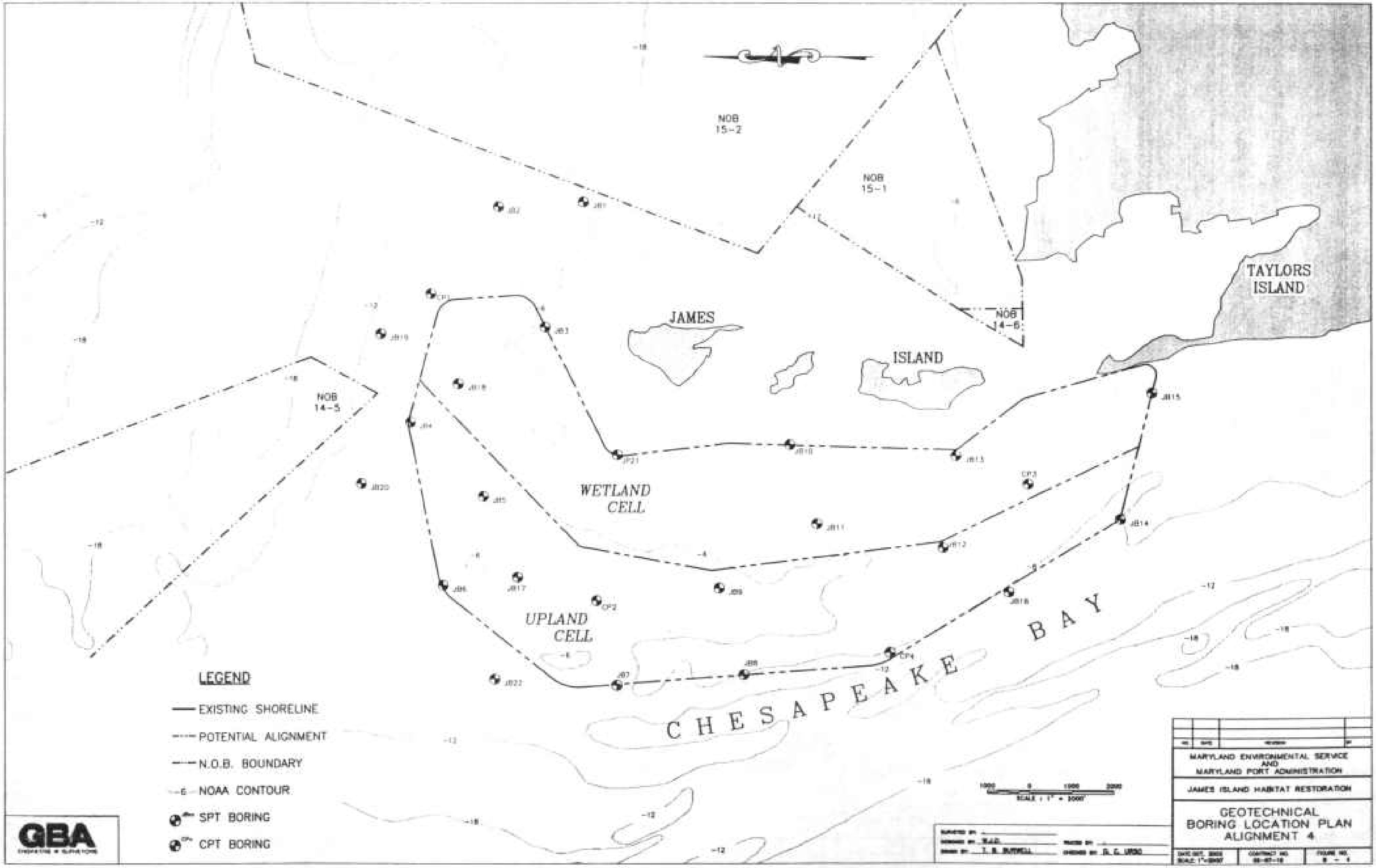
FIGURE NO.



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NOB 15-1
NOB 14-6
NOB 14-5
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JAMES
ISLAND
WETLAND CELL
UPLAND CELL
CHESAPEAKE BAY
JB15
JB14
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LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
N.O.B. BOUNDARY
NOAA CONTOUR
SPT BORING
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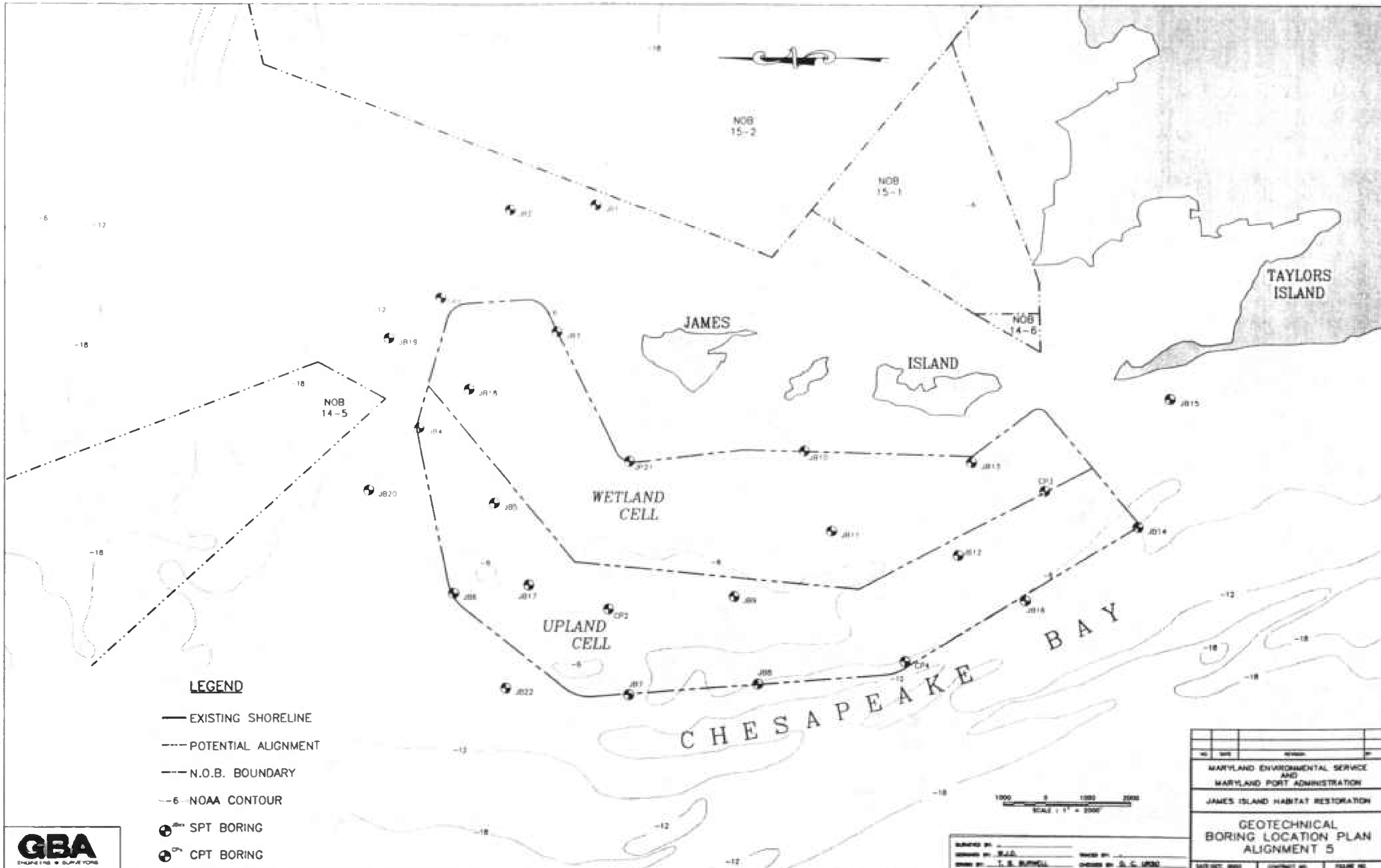
MARYLAND ENVIRONMENTAL SERVICE AND MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
GEOTECHNICAL BORING LOCATION PLAN ALIGNMENT 4



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NOB 14-6
NOB 14-5
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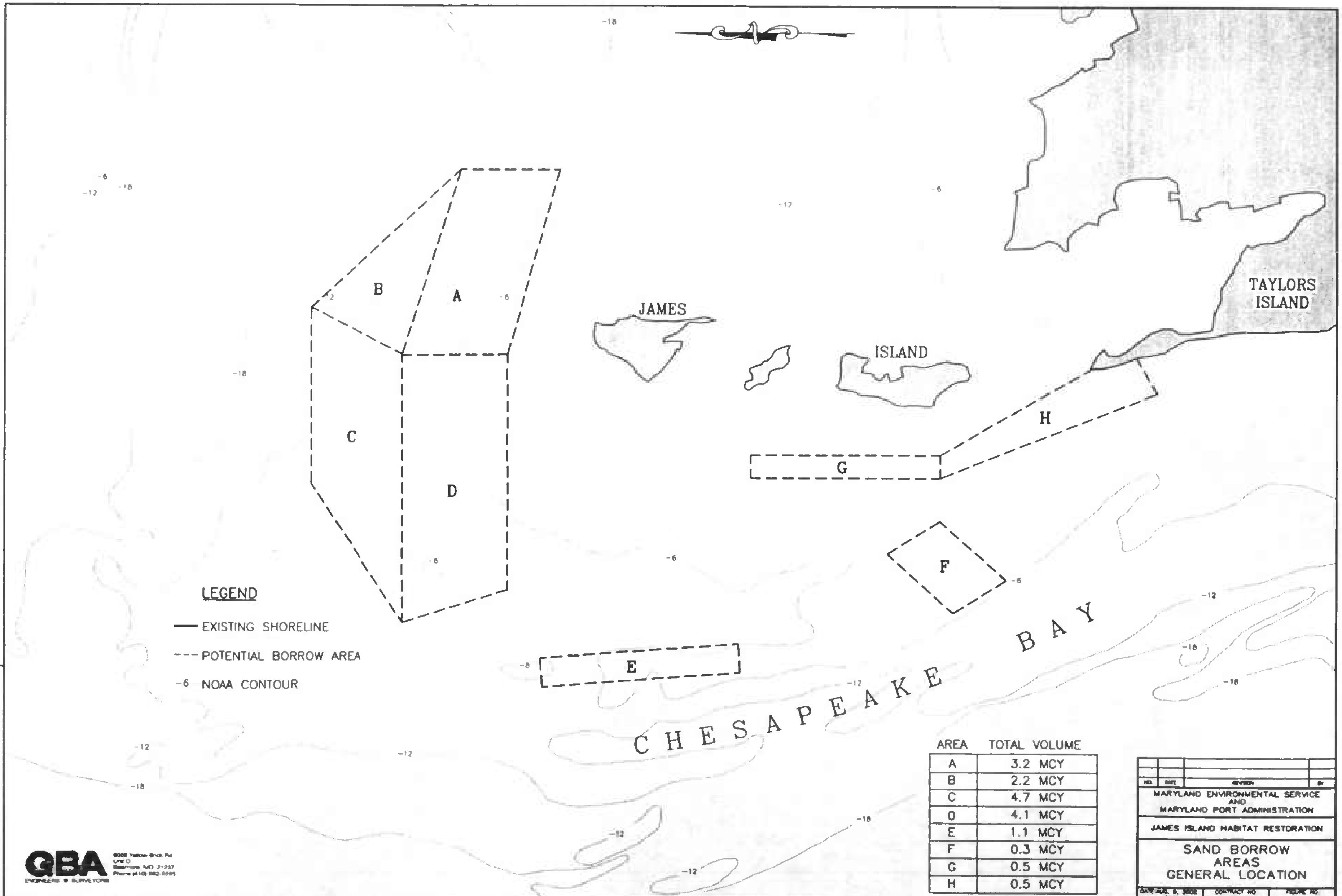
ISLAND
TAYLORS ISLAND
WETLAND CELL
UPLAND CELL
CHESAPEAKE BAY
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
N.O.B. BOUNDARY
-6 NOAA CONTOUR
SPT BORING
CPT BORING
GBA
MARYLAND ENVIRONMENTAL SERVICE AND MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
GEOTECHNICAL BORING LOCATION PLAN ALIGNMENT 5

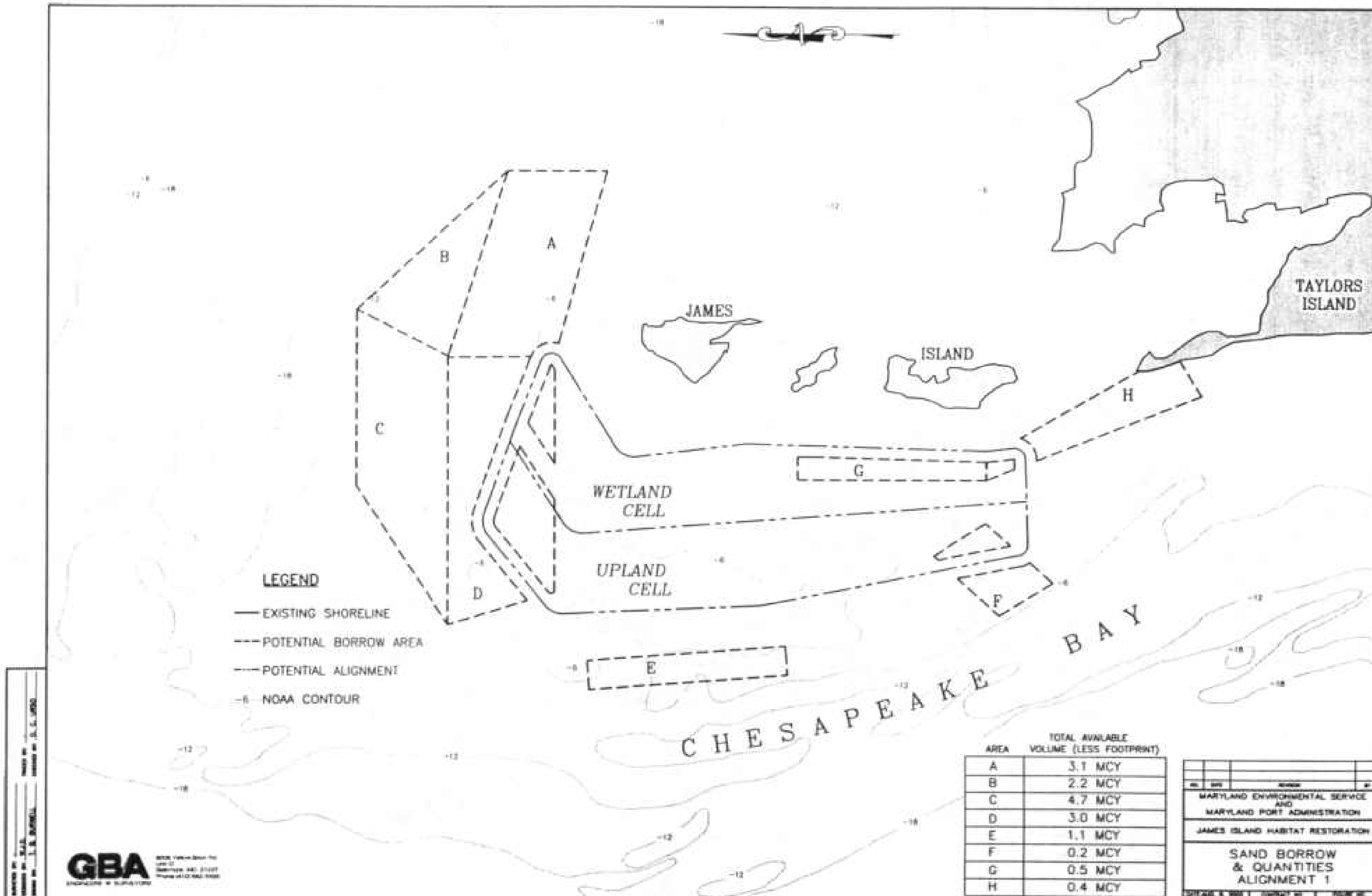


AREA	TOTAL VOLUME
A	3.2 MCY
B	2.2 MCY
C	4.7 MCY
D	4.1 MCY
E	1.1 MCY
F	0.3 MCY
G	0.5 MCY
H	0.5 MCY

MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

JAMES ISLAND HABITAT RESTORATION

SAND BORROW AREAS GENERAL LOCATION

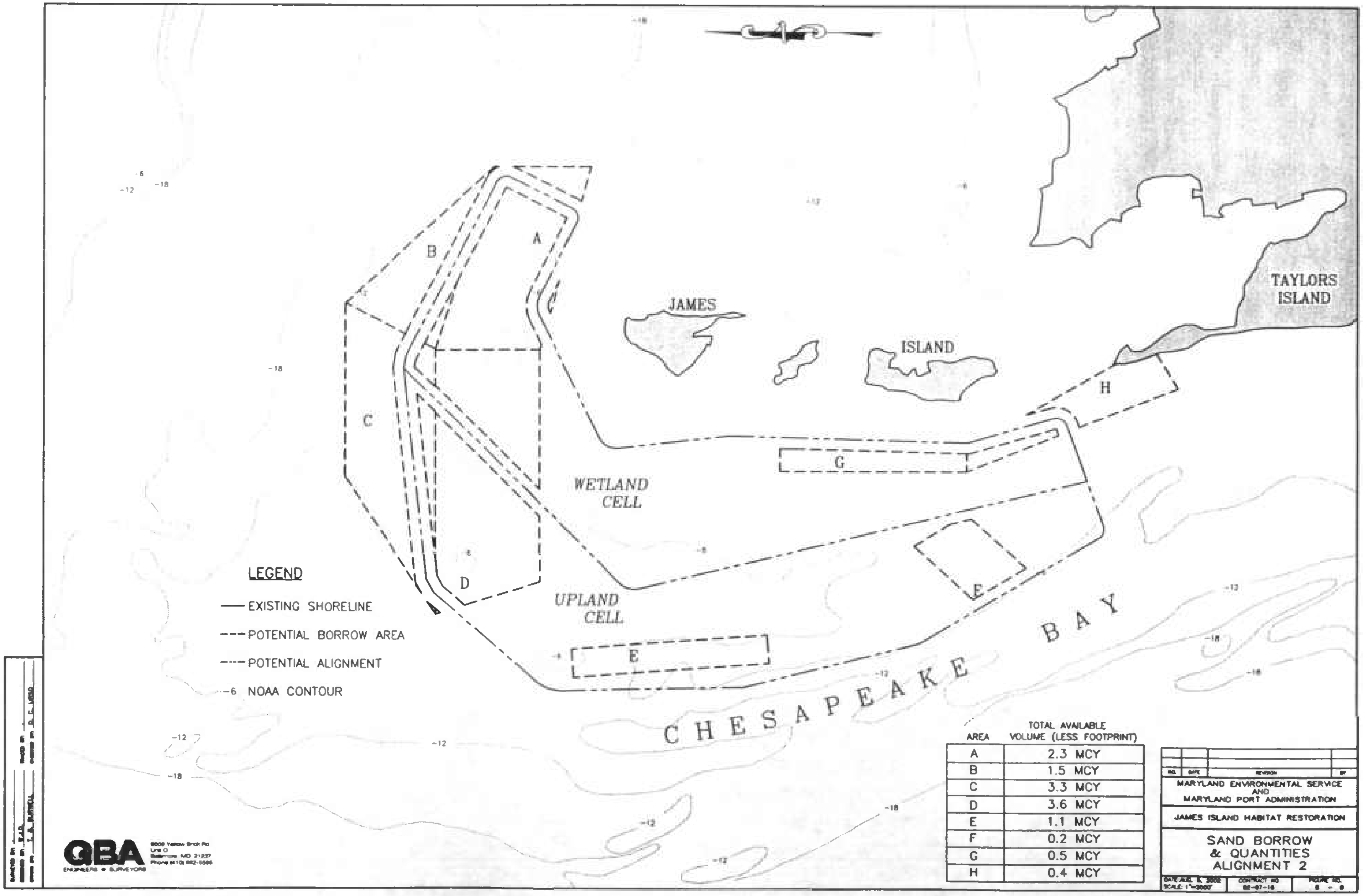


AREA	TOTAL AVAILABLE VOLUME (LESS FOOTPRINT)
A	3.1 MCY
B	2.2 MCY
C	4.7 MCY
D	3.0 MCY
E	1.1 MCY
F	0.2 MCY
G	0.5 MCY
H	0.4 MCY

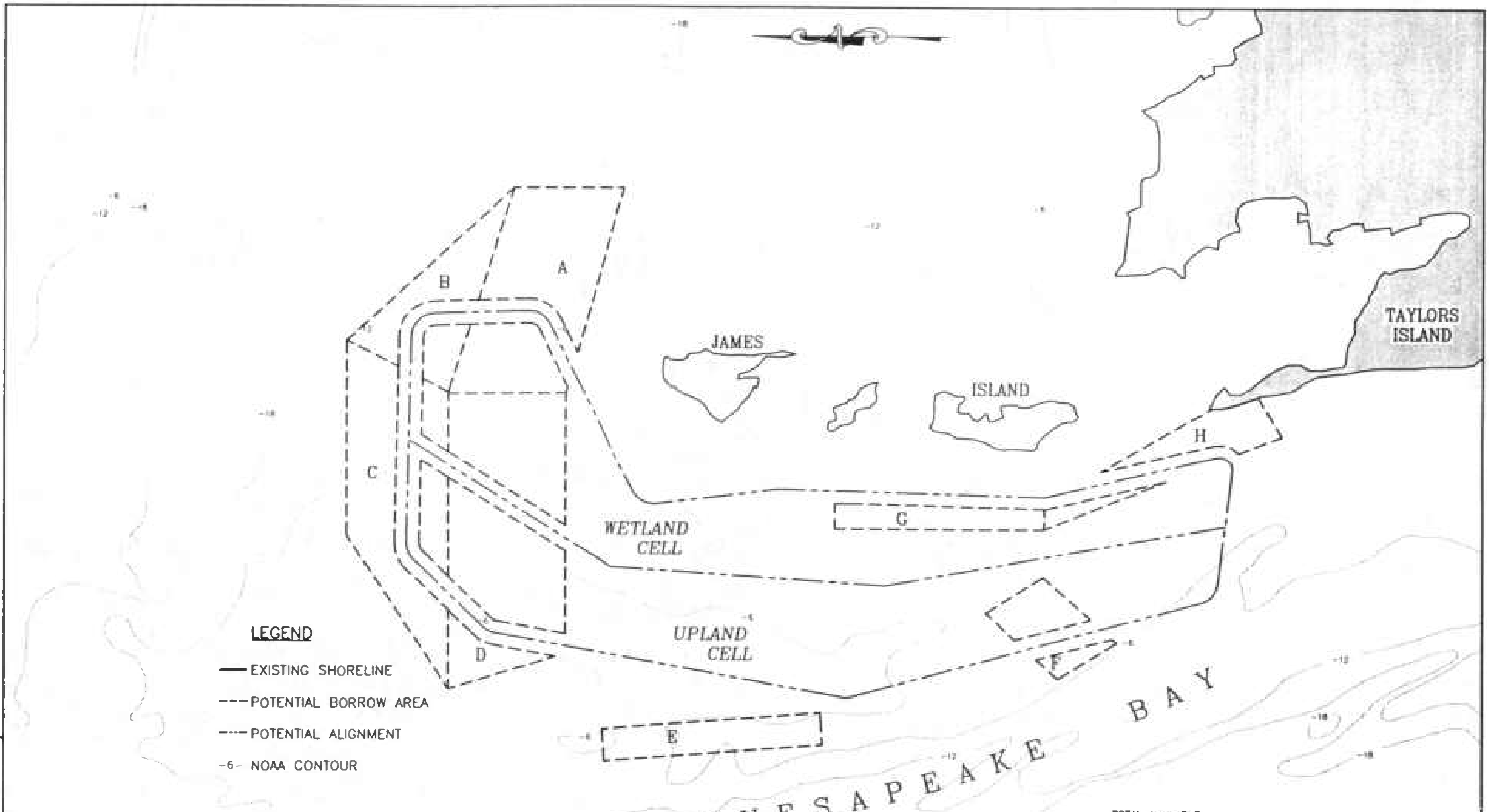
MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

JAMES ISLAND HABITAT RESTORATION

SAND BORROW
& QUANTITIES
ALIGNMENT 1



AREA	TOTAL AVAILABLE VOLUME (LESS FOOTPRINT)
A	2.3 MCY
B	1.5 MCY
C	3.3 MCY
D	3.6 MCY
E	1.1 MCY
F	0.2 MCY
G	0.5 MCY
H	0.4 MCY



AREA	TOTAL AVAILABLE VOLUME (LESS FOOTPRINT)
A	2.7 MCY
B	1.7 MCY
C	3.5 MCY
D	3.3 MCY
E	1.1 MCY
F	0.2 MCY
G	0.5 MCY
H	0.3 MCY

MARYLAND ENVIRONMENTAL SERVICE
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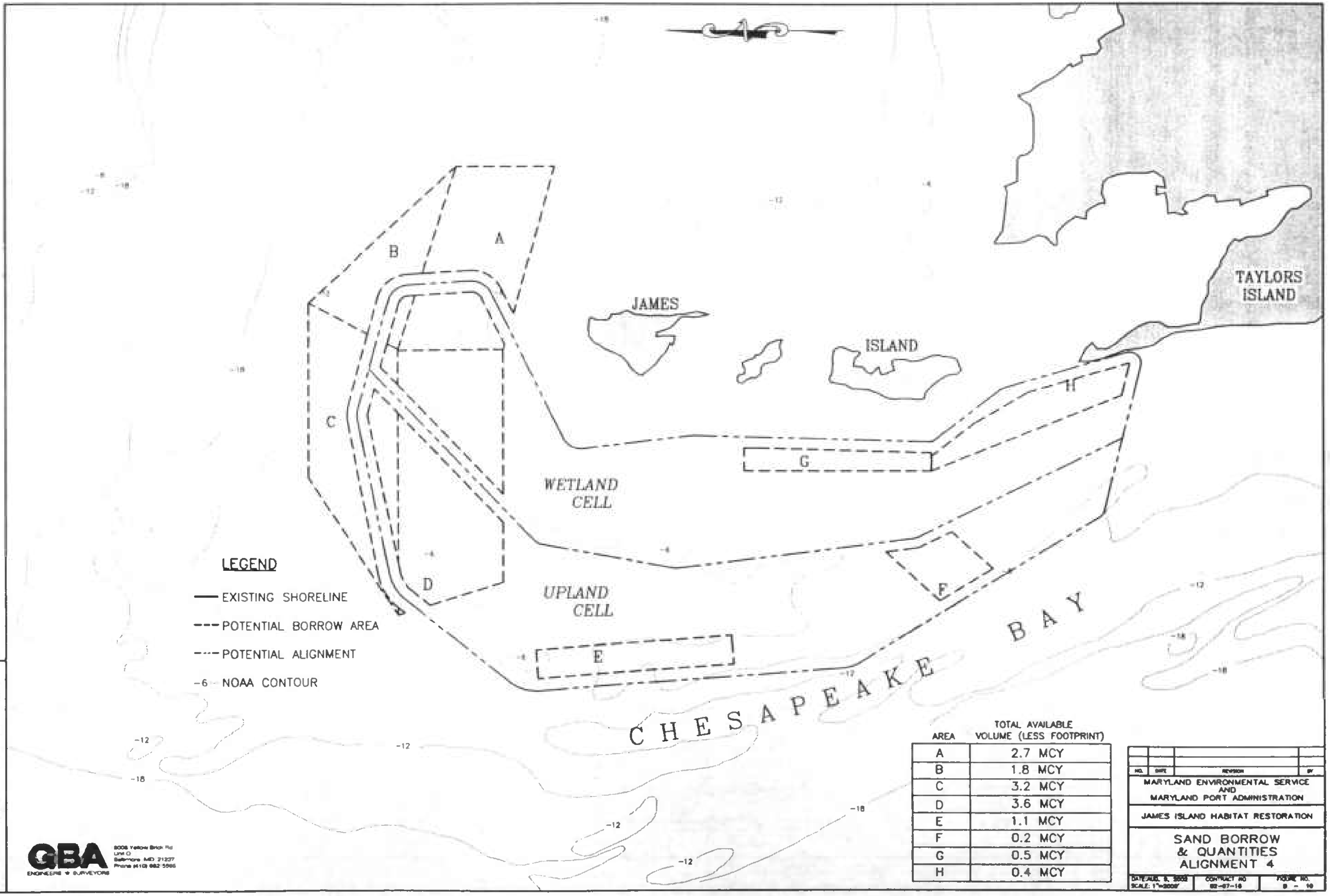
JAMES ISLAND HABITAT RESTORATION

SAND BORROW
& QUANTITIES
ALIGNMENT 3

GBA
ENGINEERS • SURVEYORS
8008 Yellow Brick Rd
Unit O
Baltimore MD 21237



AREA	TOTAL AVAILABLE VOLUME (LESS FOOTPRINT)
A	2.7 MCY
B	1.8 MCY
C	3.2 MCY
D	3.6 MCY
E	1.1 MCY
F	0.2 MCY
G	0.5 MCY
H	0.4 MCY

NO.	DATE	REVISION	BY

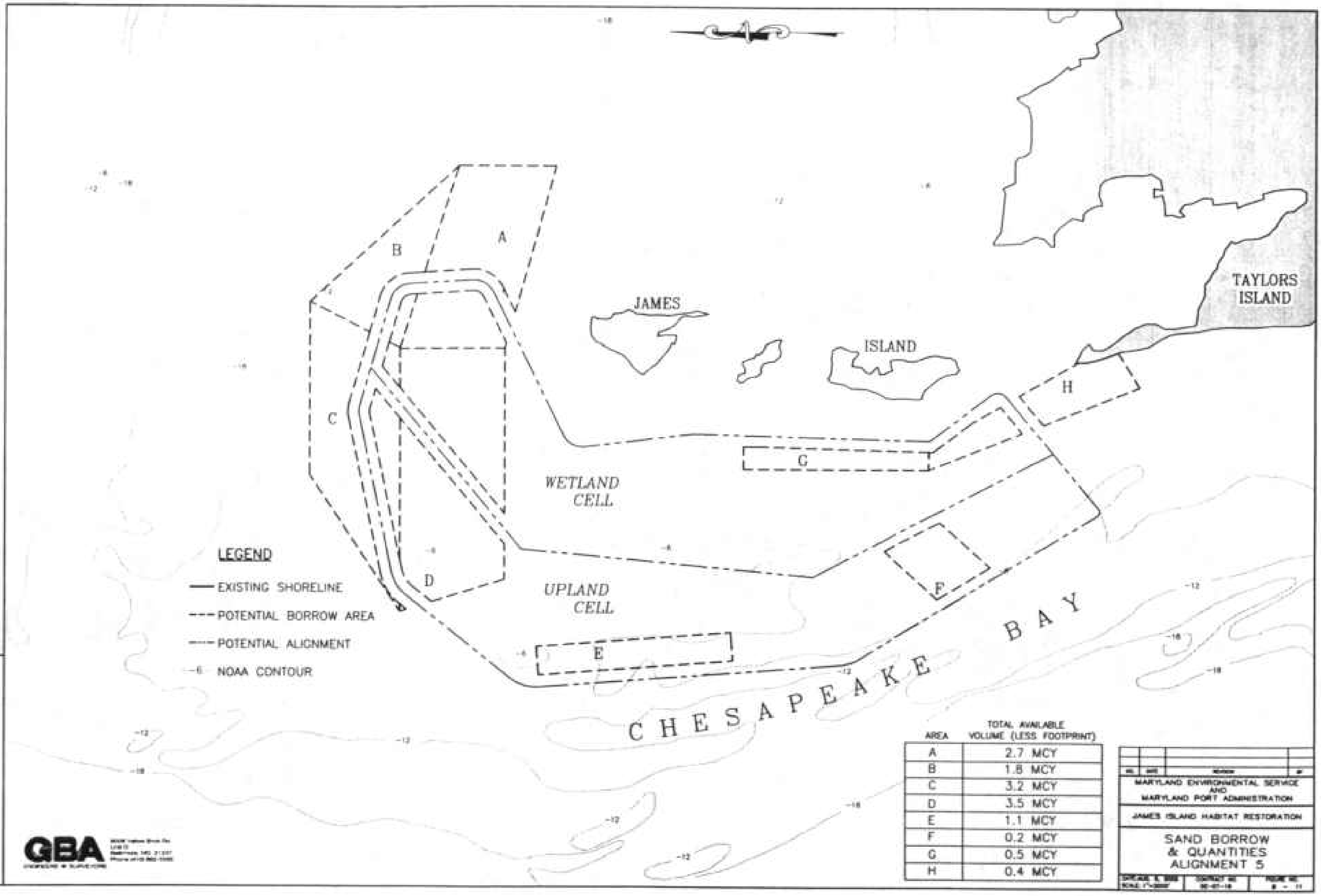
MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

JAMES ISLAND HABITAT RESTORATION

SAND BORROW
& QUANTITIES
ALIGNMENT 4

CONTRACT NO. 02-07-18

FIGURE NO. 9 - 10



AREA	TOTAL AVAILABLE VOLUME (LESS FOOTPRINT)
A	2.7 MCY
B	1.8 MCY
C	3.2 MCY
D	3.5 MCY
E	1.1 MCY
F	0.2 MCY
G	0.5 MCY
H	0.4 MCY

MARYLAND ENVIRONMENTAL SERVICE
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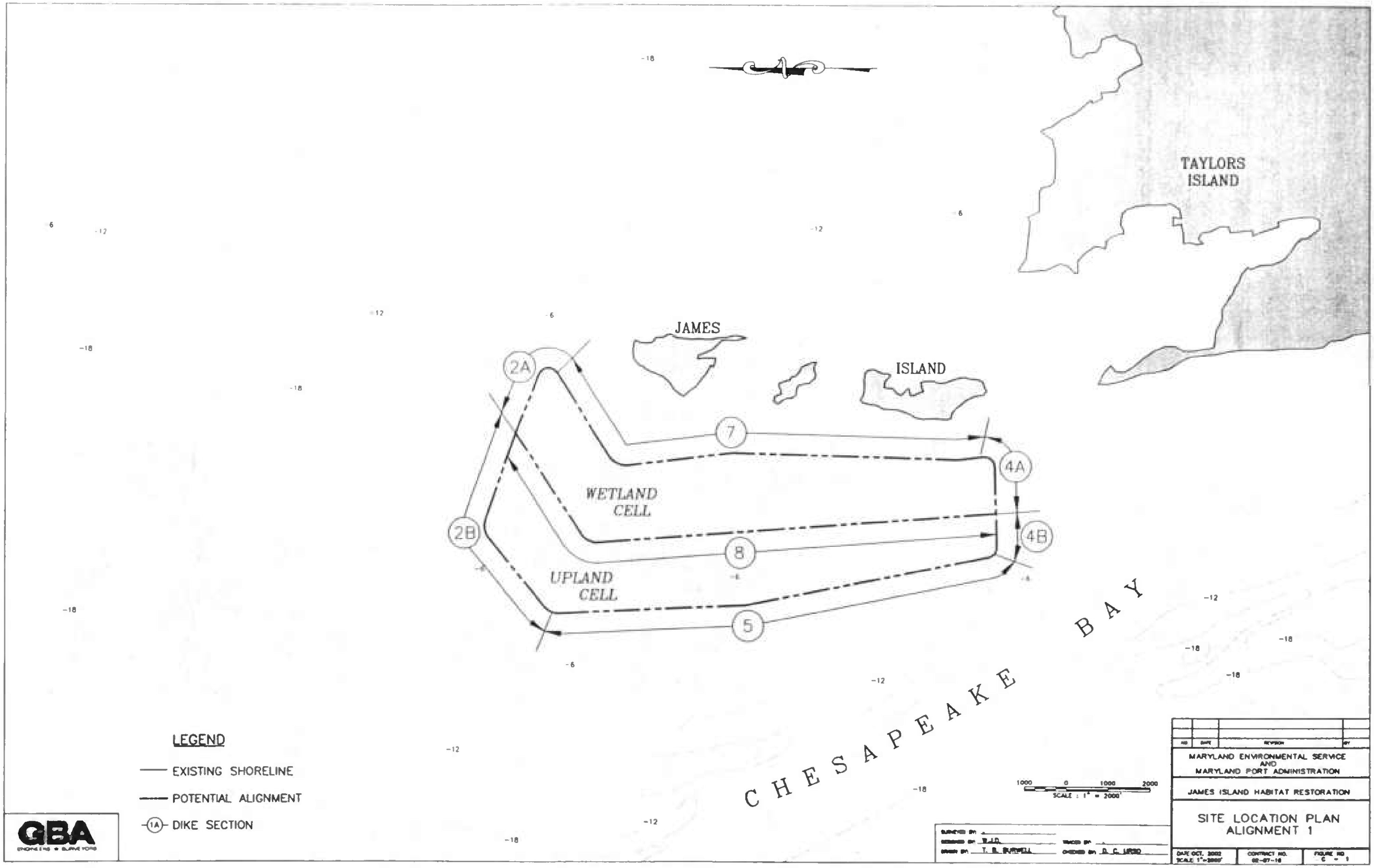
MARYLAND PORT ADMINISTRATION

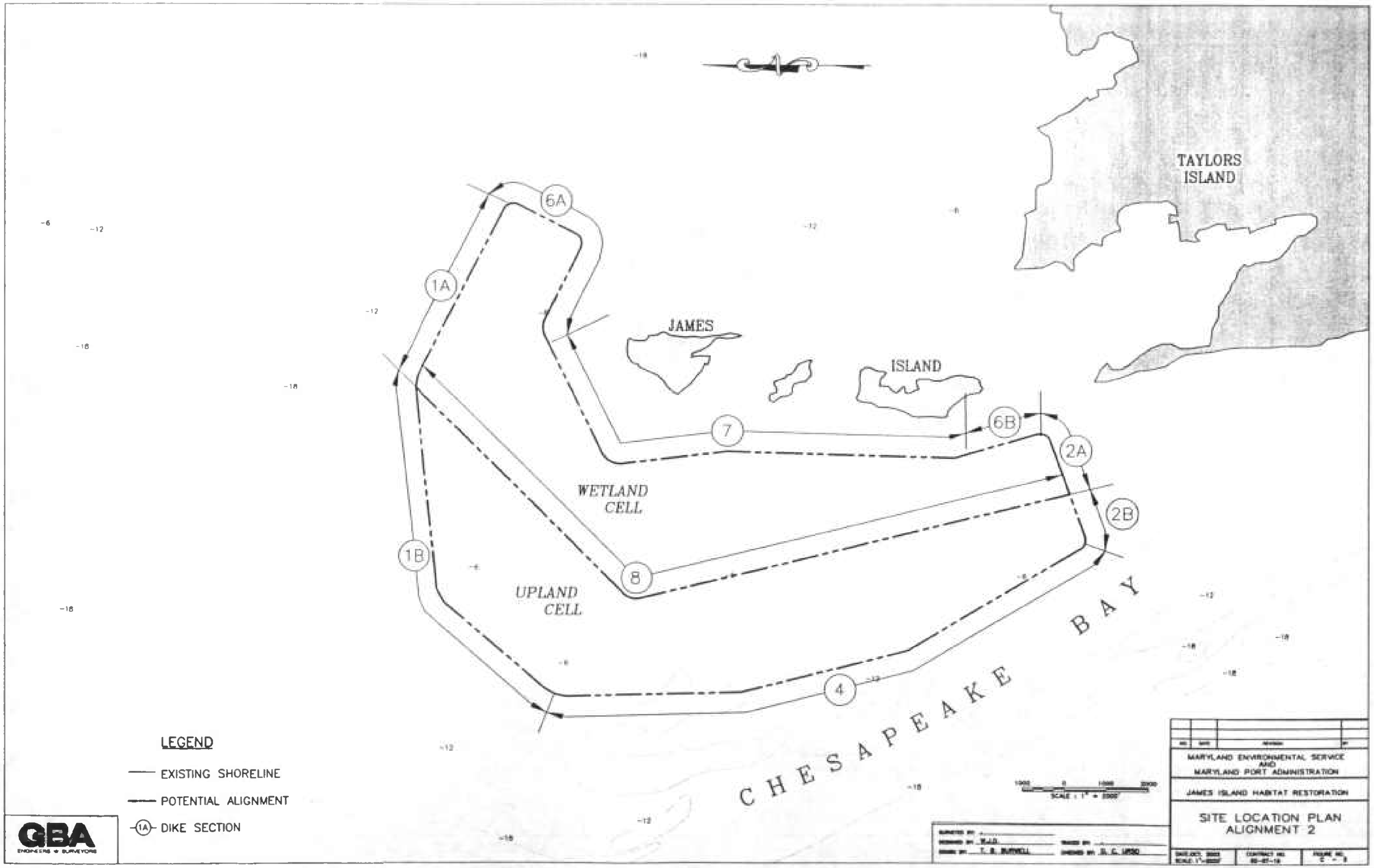
JAMES ISLAND HABITAT RESTORATION

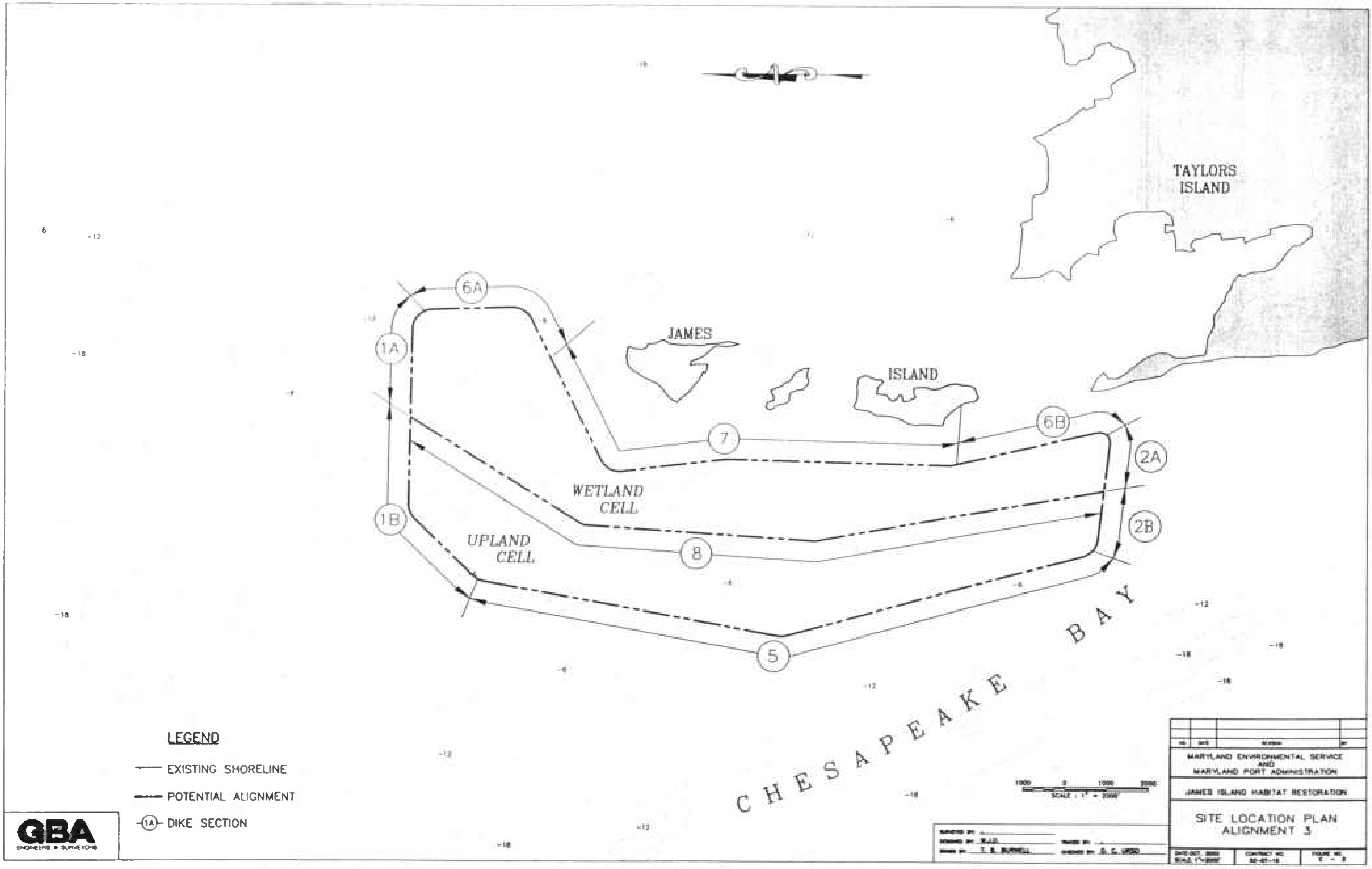
SAND BORROW
& QUANTITIES
ALIGNMENT 5

APPENDIX C

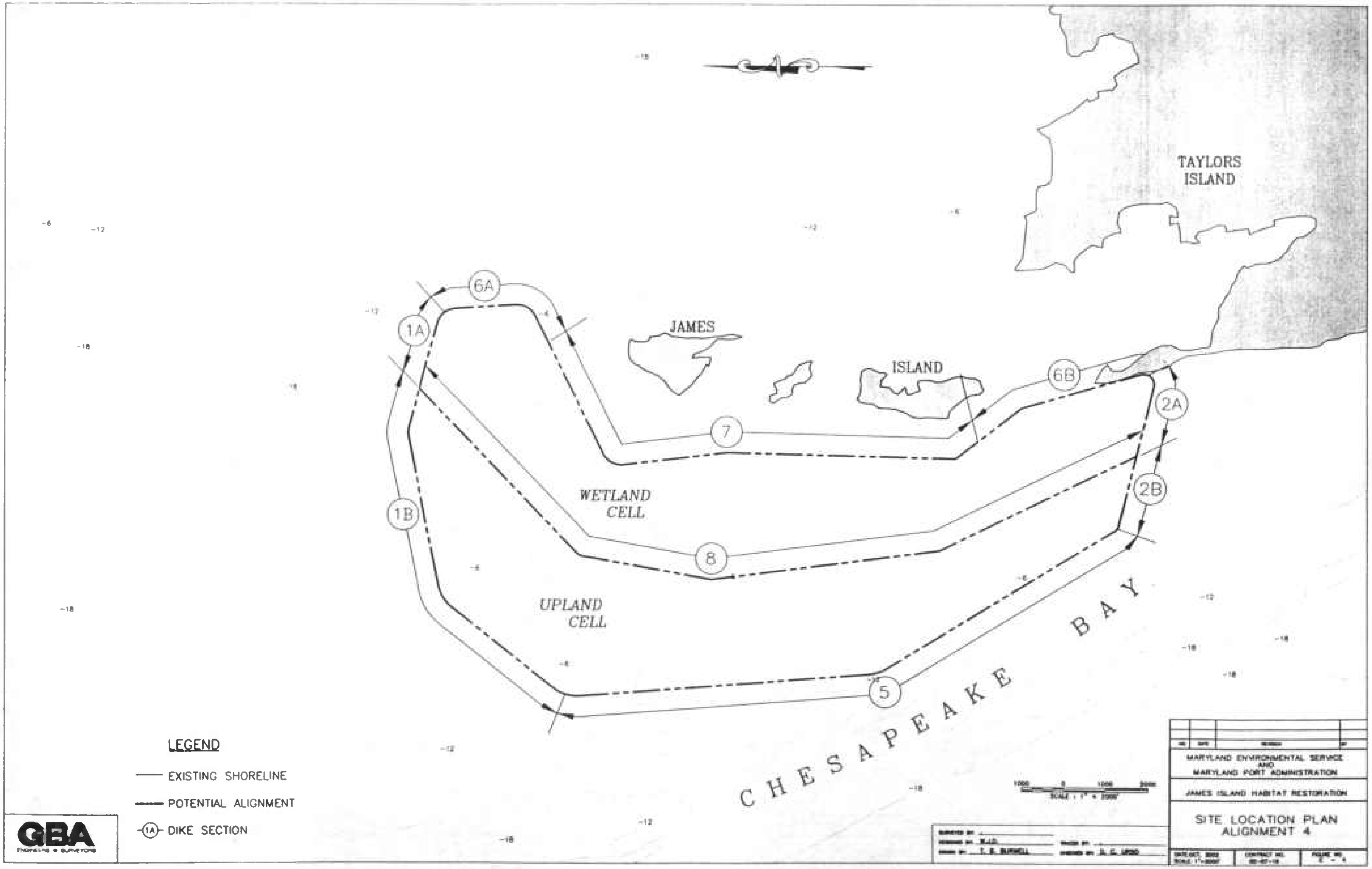
SITE LOCATION PLANS & CROSS-SECTIONS


TAYLORS ISLAND
JAMES
ISLAND
WETLAND CELL
UPLAND CELL
2A
2B
7
8
5
4A
4B
CHESAPEAKE BAY
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
1A DIKE SECTION
GBA
1000 0 1000 2000
SCALE : 1" = 2000'
MARYLAND ENVIRONMENTAL SERVICE AND MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
SITE LOCATION PLAN
ALIGNMENT 1
DATE OCT. 2002
CONTRACT NO. 02-07-16
FIGURE NO. C - 1

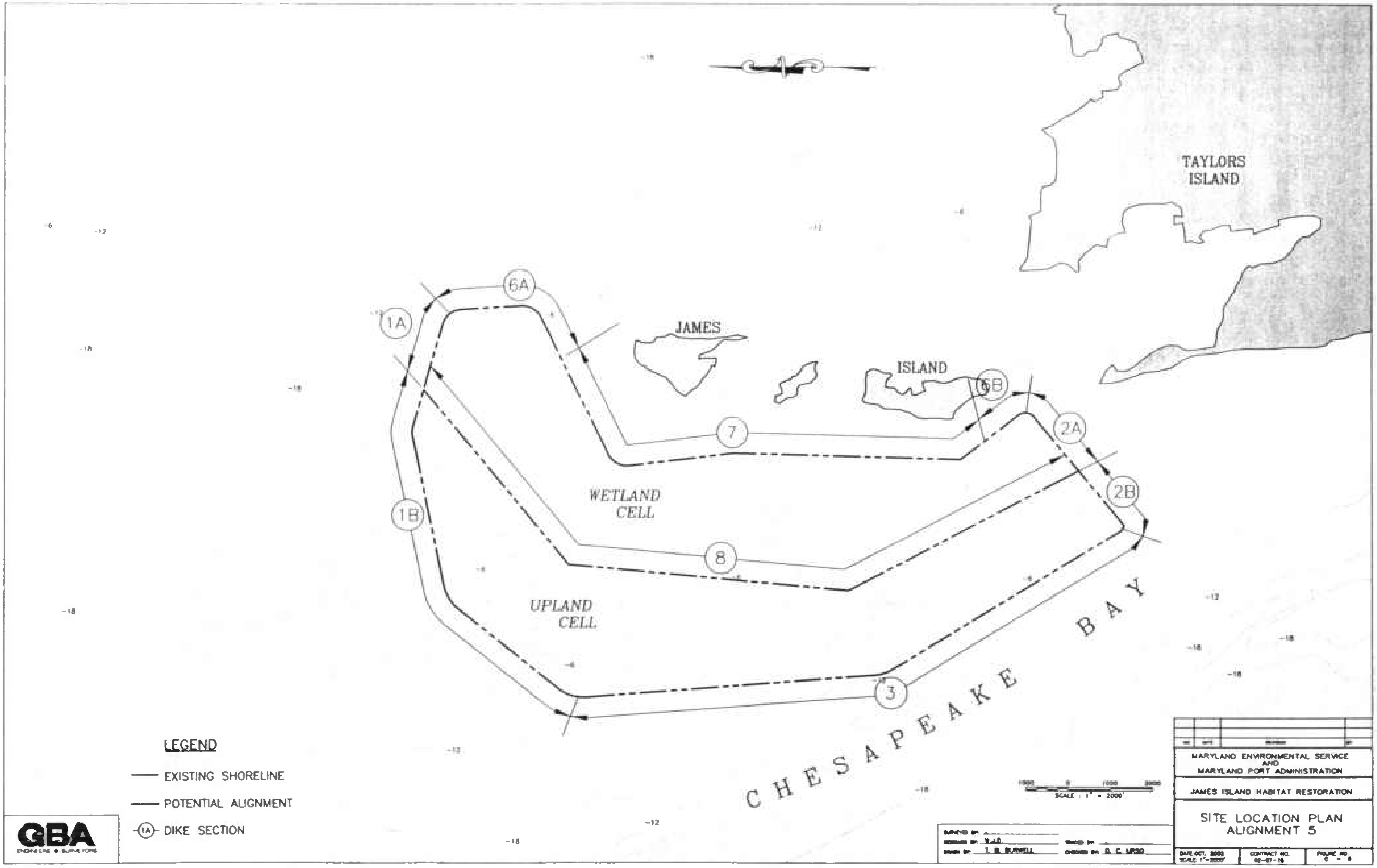

TAYLORS ISLAND
JAMES
ISLAND
6A
1A
7
6B
2A
2B
WETLAND CELL
UPLAND CELL
1B
8
4
CHESAPEAKE BAY
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
1A DIKE SECTION
GBA
MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
SITE LOCATION PLAN
ALIGNMENT 2
T. B. BURWELL



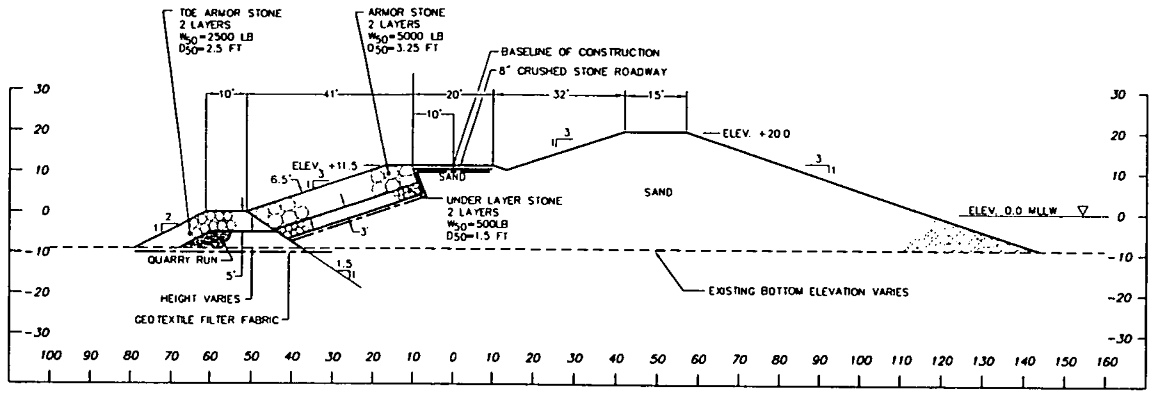
TAYLORS ISLAND
JAMES
ISLAND
WETLAND CELL
UPLAND CELL
6A
1A
1B
7
6B
2A
2B
8
5
CHESAPEAKE BAY
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
1A DIKE SECTION
GBA
SCALE : 1" = 2000'
MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
SITE LOCATION PLAN
ALIGNMENT 3



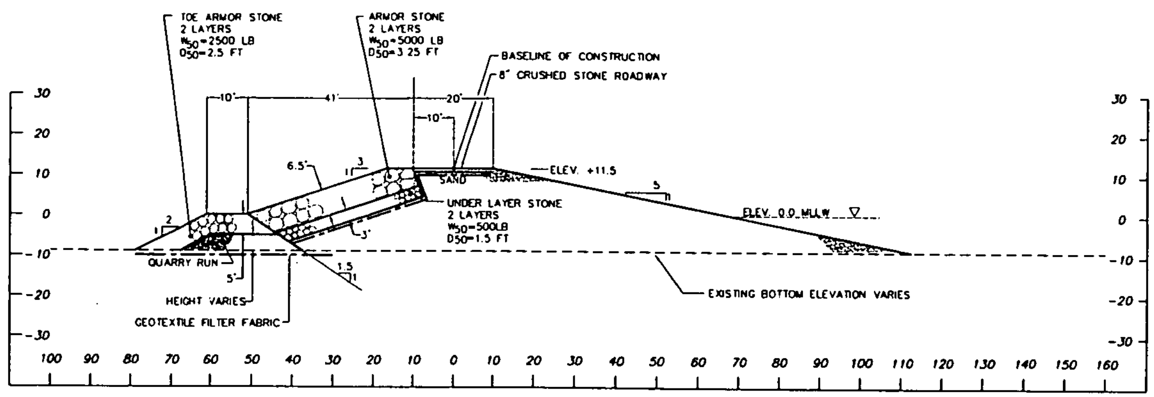
TAYLORS ISLAND
JAMES
ISLAND
WETLAND CELL
UPLAND CELL
CHESAPEAKE BAY
1A
1B
2A
2B
5
6A
6B
7
8
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
DIKE SECTION
GBA
MARYLAND ENVIRONMENTAL SERVICE AND MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
SITE LOCATION PLAN ALIGNMENT 4



TAYLORS ISLAND
JAMES
ISLAND
1A
6A
6B
7
2A
2B
1B
8
3
WETLAND CELL
UPLAND CELL
CHESAPEAKE BAY
LEGEND
EXISTING SHORELINE
POTENTIAL ALIGNMENT
1A DIKE SECTION
GBA
SCALE : 1" = 2000'
MARYLAND ENVIRONMENTAL SERVICE AND MARYLAND PORT ADMINISTRATION
JAMES ISLAND HABITAT RESTORATION
SITE LOCATION PLAN
ALIGNMENT 5



TYPICAL DIKE SECTION NO. 1 TO 20 FEET



TYPICAL DIKE SECTION NO. 1 TO 11.5 FEET

LEGEND

- — — — EXISTING GROUND
- ——— PROPOSED DIKE
- —·— — GEOTEXTILE

SCALE
15 0 7.5 15 30
FEET

GBA
ENGINEERS + SURVEYORS

SURVEYED BY:
DESIGNED BY: W.J.D.
DRAWN BY: T. B. BURWELL
TRACED BY:
CHECKED BY: D. C. URSO

NO.	DATE	REVISION	BY

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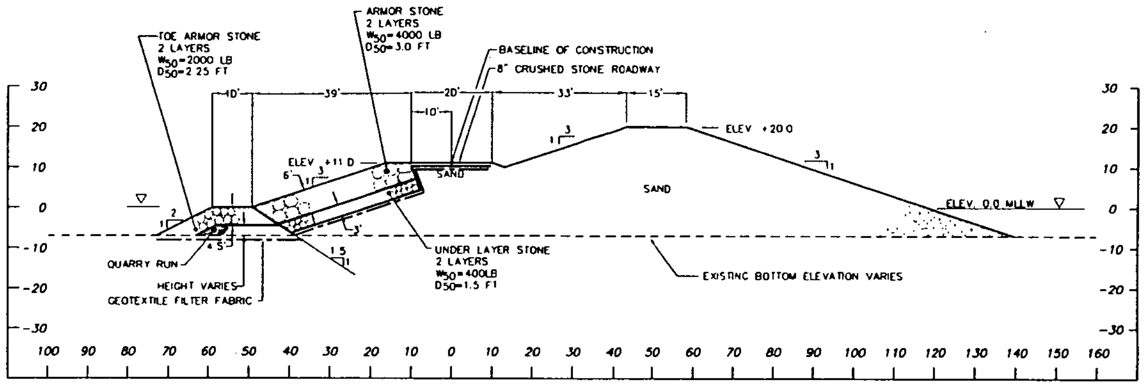
AND
MARYLAND PORT ADMINISTRATION

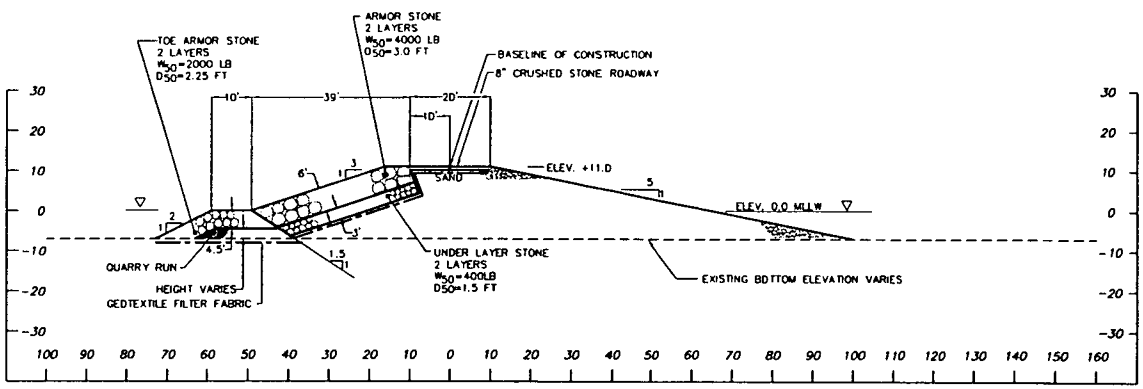
JAMES ISLAND HABITAT RESTORATION

TYPICAL DIKE SECTION
NO. 1

DATE: OCT. 2002 SCALE: 1"=30'	CONTRACT NO. 02-07-18	FIGURE NO. C - 8



TYPICAL DIKE SECTION NO. 2 TO 20 FEET



TYPICAL DIKE SECTION NO. 2 TO 11 FEET

LEGEND

- — — — EXISTING GROUND
- ——— PROPOSED DIKE
- — - — GEOTEXTILE

SCALE
15 0 7.5 15 30
FEET

GBA
ENGINEERS + SURVEYORS

SURVEYED BY: ...
DESIGNED BY: W.J.D.
DRAWN BY: T. B. BURWELL
TRACED BY: ...
CHECKED BY: D. C. URSO

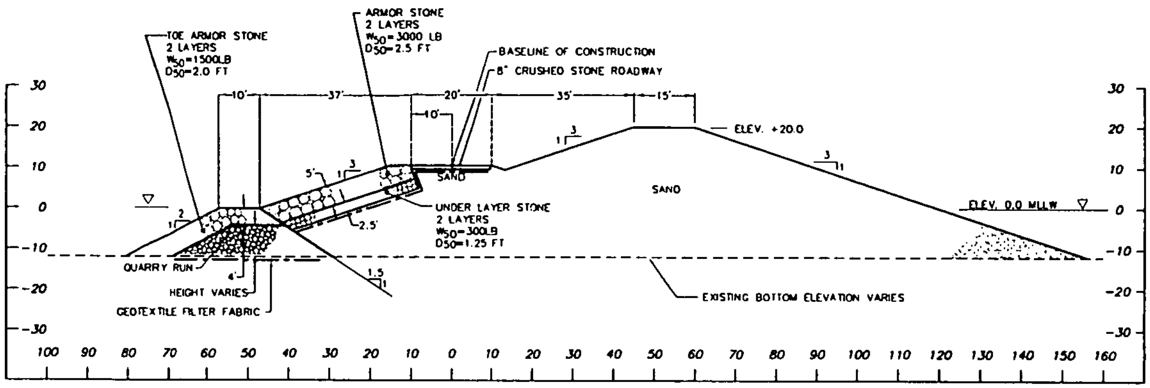
NO.	DATE	REVISION	BY

MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

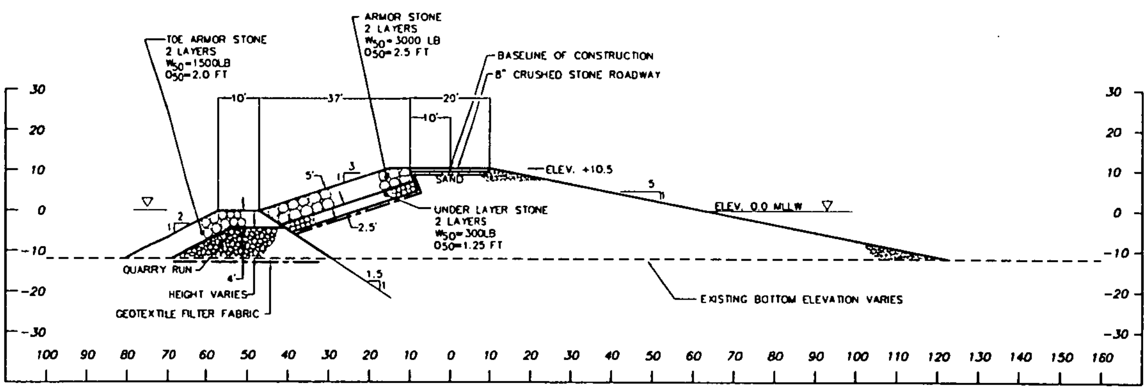
JAMES ISLAND HABITAT RESTORATION

TYPICAL DIKE SECTION
NO. 2

DATE: OCT. 2002 SCALE: 1"=30'	CONTRACT NO. 02-07-18	FIGURE NO. C - 7



TYPICAL DIKE SECTION NO. 3 to 20 FEET



TYPICAL DIKE SECTION NO. 3 to 10.5 FEET

LEGEND

- — — — EXISTING GROUND
- ——— PROPOSED DIKE
- — - — GEOTEXTILE

SCALE
15 0 7.5 15 30
FEET

NO.	DATE	REVISION	BY

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MARYLAND PORT ADMINISTRATION

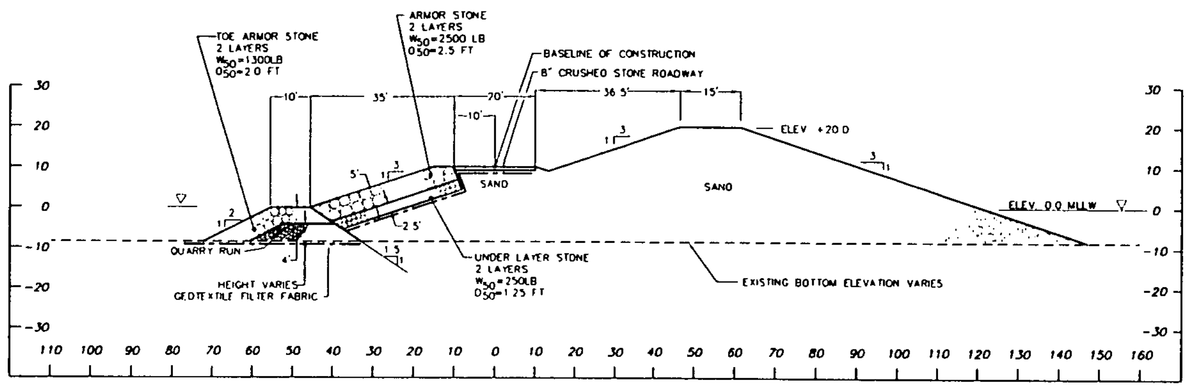
JAMES ISLAND HABITAT RESTORATION

TYPICAL DIKE SECTION
NO. 3

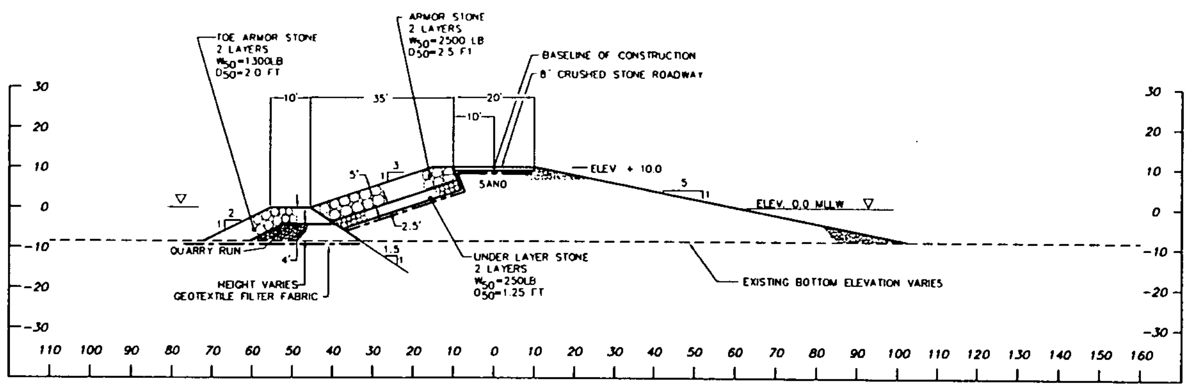
SURVEYED BY: ______
DESIGNED BY: W.J.D.
DRAWN BY: T. B. BURWELL
TRACED BY: ______
CHECKED BY: D. C. URSO

DATE: OCT. 2002 SCALE: 1"=30'	CONTRACT NO. 02-07-18	FIGURE NO. C - 8

GBA
ENGINEERS & SURVEYORS



TYPICAL DIKE SECTION NO. 4 TO 20 FEET



TYPICAL DIKE SECTION NO. 4 TO 10 FEET

LEGEND

- EXISTING GROUND
- PROPOSED DIKE
- GEOTEXTILE

SCALE
15 0 7.5 15 30
FEET

MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

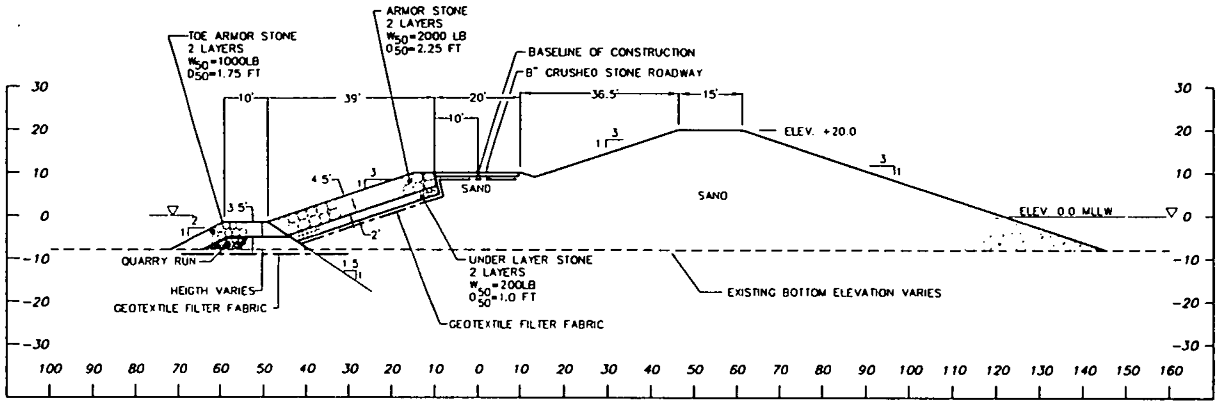
JAMES ISLAND HABITAT RESTORATION

TYPICAL DIKE SECTION NO. 4

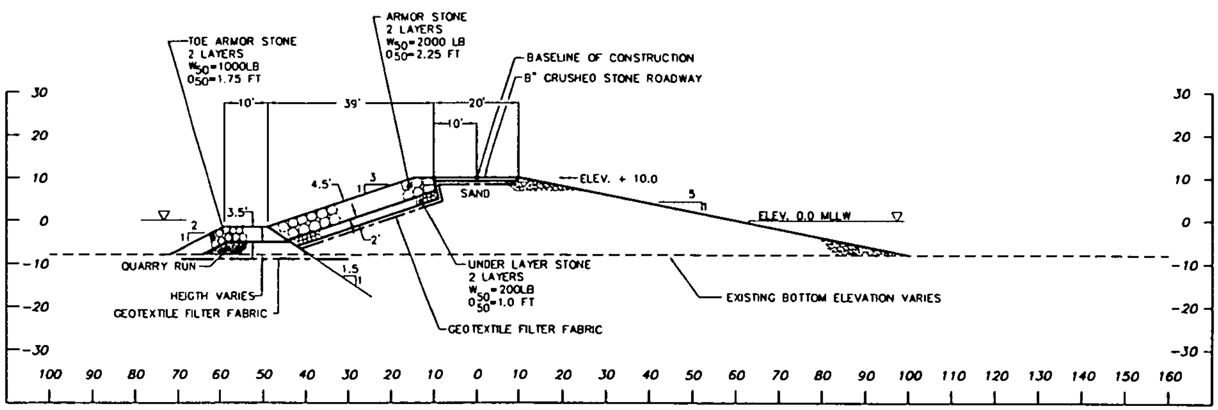
DESIGNED BY: W.J.D.
DRAWN BY: T. B. BURWELL
CHECKED BY: D. C. URSO

DATE: OCT. 2002
SCALE: 1"=30'
CONTRACT NO. 02-07-16
FIGURE NO. C-8

GBA
ENGINEERS & SURVEYORS



TYPICAL DIKE SECTION NO. 5 TO 20 FEET



TYPICAL DIKE SECTION NO. 5 TO 10 FEET

LEGEND

- EXISTING GROUND
- PROPOSED DIKE
- GEOTEXTILE

SCALE
15 0 7.5 15 30
FEET

MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

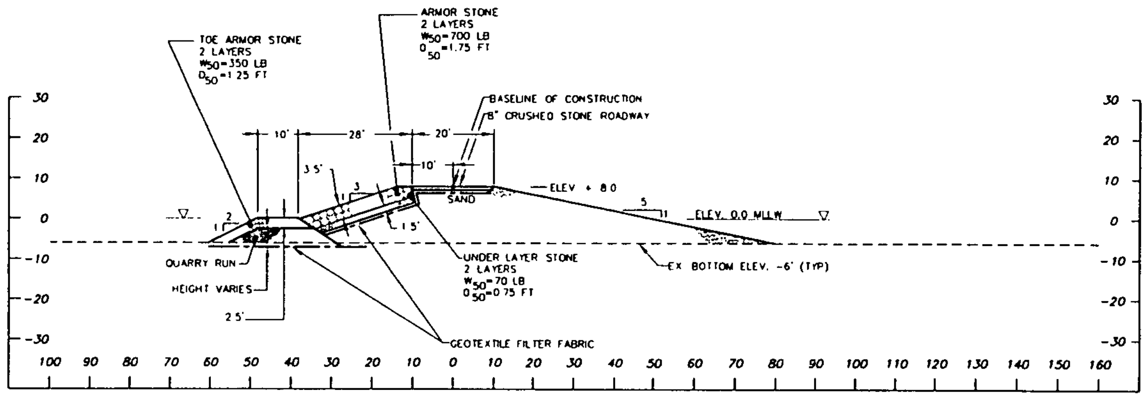
JAMES ISLAND HABITAT RESTORATION

TYPICAL DIKE SECTION
NO. 5

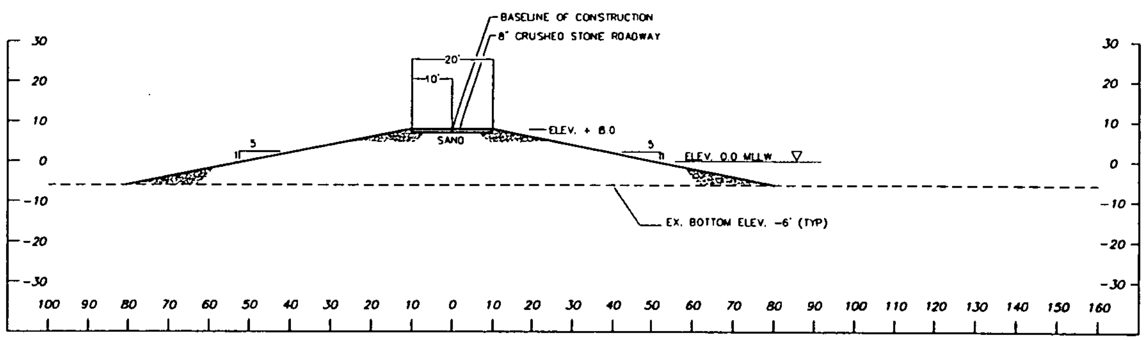
DATE: OCT. 2002
SCALE: 1"=30'
CONTRACT NO. 02-07-18
FIGURE NO. C - 10

DESIGNED BY: W.J.D.
DRAWN BY: T. B. BURWELL
CHECKED BY: D. C. URSO

GBA
ENGINEERS • SURVEYORS



TYPICAL DIKE SECTION NO. 6 TO 8'



TYPICAL DIKE SECTION NO. 7 TO 8'

LEGEND

- — — — EXISTING GROUND
- ——— PROPOSED DIKE
- — - — GEOTEXTILE

SCALE
15 0 7.5 15 30
FEET

MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

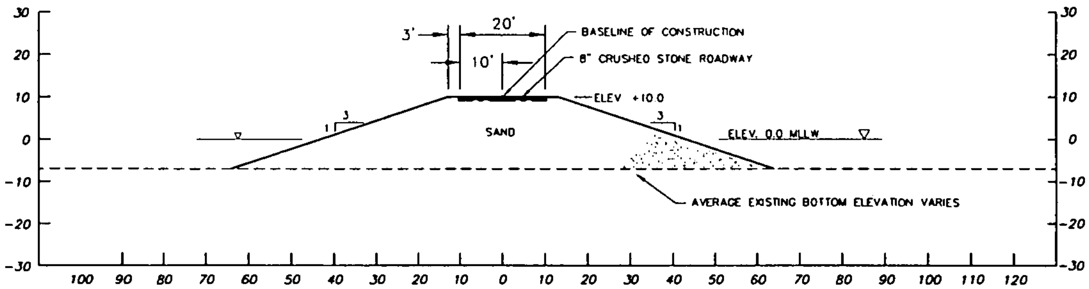
JAMES ISLAND HABITAT RESTORATION

TYPICAL DIKE SECTION
NO. 6 & NO. 7

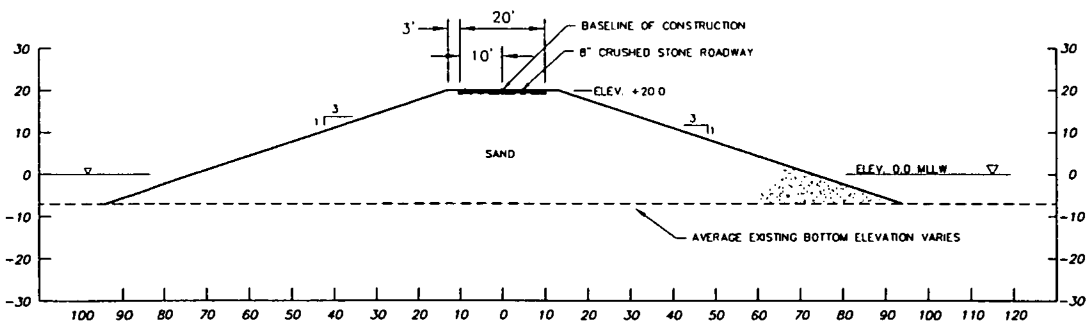
DESIGNED BY: W.I.D.
DRAWN BY: T. B. BURWELL
CHECKED BY: D. C. URSO

DATE: OCT. 2002
SCALE: 1"=30'
CONTRACT NO. 02-07-16
FIGURE NO. C – 11

GBA
ENGINEERS • SURVEYORS



TYPICAL LONGITUDINAL DIKE SECTION TO 10'



TYPICAL LONGITUDINAL DIKE SECTION TO 20'

LEGEND

- — — — EXISTING GROUND
- ———— PROPOSED DIKE
- — - — GEOTEXTILE

SCALE

15 0 7.5 15 30

FEET

GBA

ENGINEERS & SURVEYORS

SURVEYED BY: _

DESIGNED BY: W.J.D.

DRAWN BY: T. B. BURWELL

TRACED BY: _

CHECKED BY: D. C. URSO

NO.	DATE	REVISION	BY

MARYLAND ENVIRONMENTAL SERVICE
AND
MARYLAND PORT ADMINISTRATION

JAMES ISLAND HABITAT RESTORATION

TYPICAL LONGITUDINAL
DIKE SECTION NO. 8

DATE: OCT. 2003 SCALE: 1"=30'	CONTRACT NO. 02-07-18	FIGURE NO. C - 12

APPENDIX D

PRELIMINARY SITE CHARACTERISTICS & MATERIAL QUANTITIES

James Island Habitat Development

Table D-1 - Preliminary Site Characteristics and Quantities Alignment No. 1

SITE CHARACTERISTICS	Alignment No. 1 (20 ft)		Alignment No. 1 (10 ft)	
Upland Baseline Area -	489.3	Acres	489.3	Acres
Upland Baseline Perimeter -	29,951	LF	29,951	LF
Upland Site Volume below sea level -	4.7	MCY	4.7	MCY
Upland Site Volume above sea level -	14.2	MCY	6.3	MCY
Upland Site Volume -	18.9	MCY	11.1	MCY
Upland Site Capacity -	28.2	MCY	16.0	MCY
Wetland Baseline Area -	489.4	Acres	489.4	Acres
Wetland Baseline Perimeter -	28,230	LF	28,230	LF
Wetland Site Volume below sea level -	3.6	MCY	3.6	MCY
Wetland Site Volume above sea level -	1.2	MCY	1.2	MCY
Wetland Site Volume -	4.7	MCY	4.7	MCY
Wetland Site Capacity -	6.6	MCY	6.6	MCY
Total Baseline Area -	978.6	Acres	978.6	Acres
Total Baseline Perimeter -	32,102	LF	32,102	LF
Total Interior Dike -	13,039	LF	13,039	LF
Total Volume -	23.7	MCY	15.8	MCY
Total Site Capacity -	34.7	MCY	22.6	MCY

QUANTITIES	Alignment No. 1 (20 ft)			Alignment No. 1 (10 ft)		
	LF	CY/LF	CY	LF	CY/LF	CY
Hydraulic Fill Material						
Unsuitable Backfill -			1,118,000			976,000
Wetland Perimeter Dike Section 2A to +11 -	2,098	42.0	88,000	2,098	42.0	88,000
Upland Perimeter Dike Section 2B to +11 -				5,085	48.6	247,000
Upland Perimeter Dike Section 2B to +20 -	5,085	100.8	512,000			
Wetland Perimeter Dike Section 4A to +10 -	1,622	27.0	44,000	1,622	27.0	44,000
Upland Perimeter Dike Section 4B to +10 -				817	33.2	27,000
Upland Perimeter Dike Section 4B to +20 -	817	85.7	70,000			
Upland Perimeter Dike Section 5 to +10 -				11,009	43.6	480,000
Upland Perimeter Dike Section 5 to +20 -	11,009	99.9	1,100,000			
Wetland Perimeter Dike Section 7 to +8 -	11,471	31.6	362,000	11,471	31.6	362,000
Longitudinal Dike Section 8 to +10 -				13,039	39.0	509,000
Longitudinal Dike Section 8 to +20 -	13,039	92.9	1,211,000			
Total -	**45,141**		**4,505,000**	**45,141**		**2,733,000**

	Alignment No. 1 (20 ft)			Alignment No. 1 (10 ft)		
	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Perimeter Dike Stone Work						
Slope Armor Dike Section 2A & 2B -	7,183	12.4	89,000	7,183	12.4	89,000
Underlayer Dike Section 2A & 2B -	7,183	5.8	41,000	7,183	5.8	41,000
Toe Armor Dike Section 2A -	2,098	5.8	12,000	2,098	5.8	12,000
Quarry Run Dike Section 2A -	2,098	2.8	6,000	2,098	2.8	6,000
Toe Armor Dike Section 2B-	5,085	5.9	30,000	5,085	5.9	30,000
Quarry Run Dike Section 2B -	5,085	3.0	15,000	5,085	3.0	15,000
Slope Armor Dike Section 4A & 4B -	2,438	9.5	23,000	2,438	9.5	23,000
Underlayer Dike Section 4A & 4B -	2,438	4.4	11,000	2,438	4.4	11,000
Toe Armor Dike Section 4A -	1,622	4.9	8,000	1,622	4.9	8,000
Quarry Run Dike Section 4A -	1,622	1.6	3,000	1,622	1.6	3,000
Toe Armor Dike Section 4B -	817	4.9	4,000	817	4.9	4,000
Quarry Run Dike Section 4B -	817	1.6	1,000	817	1.6	1,000
Slope Armor Dike Section 5 -	11,009	9.5	105,000	11,009	9.5	105,000
Underlayer Dike Section 5 -	11,009	4.3	47,000	11,009	4.3	47,000
Toe Armor Dike Section 5 -	11,009	3.8	42,000	11,009	3.8	42,000
Quarry Run Dike Section 5 -	11,009	1.6	18,000	11,009	1.6	18,000
Total -	**20,631**		**455,000**	**20,631**		**455,000**
	LF	SY/LF	SY	LF	SY/LF	SY
Miscellaneous						
Road Stone -	45,141	1.1	50,000	45,141	1.1	50,000
Perimeter Geotextile -	32,102	14.5	465,000	32,102	14.5	465,000
Roadway Geotextile -	45,141	2.6	117,000	45,141	2.6	117,000

James Island Habitat Development

Teble D-2 - Preliminary Site Characteristics and Quantities Alignment No. 2

	Alignment No. 2 (20 ft)			Alignment No. 2 (10 ft)		
SITE CHARACTERISTICS						
Uplend Baseline Area -	1,063.3	Acres		1,063.3	Acres	
Uplend Baseline Perimeter -	41,816	LF		41,816	LF	
Uplend Site Volume below see level -	11.2	MCY		11.2	MCY	
Uplend Site Volume ebove sea level -	30.9	MCY		13.7	MCY	
Uplend Site Volume -	42.0	MCY		24.9	MCY	
Uplend Site Capacity -	62.4	MCY		36.0	MCY	
Wetland Beseline Area -	1,063.4	Acres		1,063.4	Acres	
Wetland Baseline Perimeter -	43,313	LF		43,313	LF	
Wetland Site Volume below sea level -	9.0	MCY		9.0	MCY	
Wetland Site Volume ebove see level -	2.6	MCY		2.6	MCY	
Wetlend Site Volume -	11.6	MCY		11.6	MCY	
Wetlend Site Cepacity -	16.0	MCY		18.0	MCY	
Totel Beseline Area -	2,126.8	Acres		2,126.8	Acres	
Totel Baseline Perimeter -	48,812	LF		48,812	LF	
Total Interior Dike -	18,159	LF		18,159	LF	
Total Volume -	53.6	MCY		36.5	MCY	
Total Site Capacity -	78.3	MCY		52.0	MCY	
	Alignment No. 2 (20 ft)			**Alignment No. 2 (10 ft)**		
QUANTITIES	LF	CY/LF	CY	LF	CY/LF	CY
Hydraulic Fill Material						
Unsuitable Backfill -			360,000			360,000
Wetland Perimeter Dike Section 1A to +11.5 -	5,037	51.1	257,000	5,037	51.1	257,000
Upland Perimeter Dike Section 1B to +11.5 -				8,773	53.2	467,000
Uplend Penmeter Dike Section 1B to +20 -	8,773	103.1	904,000			
Wetland Penmeter Dike Section 2A to +11 -	1,668	32.1	53,000	1,668	32.1	53,000
Upland Penmeter Dike Section 2B to +11 -				1,263	36.4	46,000
Upland Perimeter Dike Section 2B to +20 -	1,263	84.7	107,000			
Uplend Penmeter Dike Section 4 to +10 -				13,621	41.9	571,000
Upland Penmeter Dike Section 4 to +20 -	13,621	98.0	1,335,000			
Wetland Penmeter Dike Section 6A to +8 -	4,735	34.9	165,000	4,735	34.9	165,000
Wetlend Penmeter Dike Section 6B to +8 -	1,865	18.0	33,000	1,865	18.0	33,000
Wetland Penmeter Dike Section 7 to +8 -	11,850	33.1	392,000	11,850	33.1	392,000
Longitudinal Dike Section 8 to +10 -				18,159	44.3	805,000
Longitudinal Dike Section 8 to +20 -	18,159	100.8	1,831,000			
Total -	**66,970**		**5,437,000**	**66,970**		**3,149,000**
	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Perimeter Dike Stone Work						
Slope Armor Dike Section 1A & 1B -	13,810	14.0	194,000	13,810	14.0	194,000
Underlayer Dike Section 1A & 1B -	13,810	6.0	83,000	13,810	6.0	83,000
Toe Armor Dike Section 1A -	5,037	6.6	33,000	5,037	6.6	33,000
Quarry Run Dike Section 1A -	5,037	2.7	14,000	5,037	2.7	14,000
Toe Armor Dike Section 1B -	8,773	6.7	59,000	8,773	6.7	59,000
Quarry Run Dike Section 1B -	8,773	2.9	26,000	8,773	2.9	26,000
Slope Armor Dike Section 2A & 2B -	2,931	12.4	36,000	2,931	12.4	36,000
Underlayer Dike Section 2A & 2B -	2,931	5.8	17,000	2,931	5.8	17,000
Toe Armor Dike Section 2A -	1,668	5.8	10,000	1,668	5.8	10,000
Quarry Run Dike Section 2A -	1,668	2.8	5,000	1,668	2.8	5,000
Toe Armor Dike Section 2B -	1,263	5.9	7,000	1,263	5.9	7,000
Quarry Run Dike Section 2B -	1,263	3.0	4,000	1,263	3.0	4,000
Slope Armor Dike Section 4 -	13,621	9.5	129,000	13,621	9.5	129,000
Underlayer Dike Section 4 -	13,621	4.4	60,000	13,621	4.4	60,000
Toe Armor Dike Section 4 -	13,621	5.2	71,000	13,621	5.2	71,000
Quarry Run Dike Section 4 -	13,621	2.1	29,000	13,621	2.1	29,000
Slope Armor Dike Section 6A -	4,735	5.2	25,000	4,735	5.2	25,000
Underlayer Dike Section 6A -	4,735	2.1	10,000	4,735	2.1	10,000
Toe Armor Dike Section 6A -	4,735	3.2	15,000	4,735	3.2	15,000
Quarry Run Dike Section 6A -	4,735	5.2	25,000	4,735	5.2	25,000
Slope Armor Dike Section 6B -	1,865	5.0	9,000	1,865	5.0	9,000
Underlayer Dike Section 6B -	1,865	1.5	3,000	1,865	1.5	3,000
Toe Armor Dike Section 6B -	1,865	2.5	5,000	1,865	2.5	5,000
Quarry Run Dike Section 6B -	1,865	1.7	3,000	1,865	1.7	3,000
Total -	**36,961**		**872,000**	**36,961**		**872,000**
	LF	SY/LF	SY	LF	SY/LF	SY
Miscellaneous						
Road Stone -	66,970	1.1	74,000	66,970	1.1	74,000
Penmeter Geotextile -	48,812	14.5	708,000	48,812	14.5	708,000
Roadway Geotextile -	66,970	2.8	174,000	66,970	2.6	174,000

James Island Habitat Development

Table D-3 - Preliminary Site Characteristics and Quantities Alignment No. 3

	Alignment No. 3 (20 ft)			Alignment No. 3 (10 ft)		
SITE CHARACTERISTICS						
Upland Baseline Area -	793	Acres		793	Acres	
Upland Baseline Perimeter -	39,033	LF		39,033	LF	
Upland Site Volume below sea level -	7.7	MCY		7.7	MCY	
Upland Site Volume above sea level -	23.0	MCY		10.2	MCY	
Upland Site Volume -	30.7	MCY		17.9	MCY	
Upland Site Capacity -	45.7	MCY		26.0	MCY	
Wetland Baseline Area -	793	Acres		793	Acres	
Wetland Baseline Perimeter -	40,712	LF		40,712	LF	
Wetland Site Volume below sea level -	6.4	MCY		6.4	MCY	
Wetland Site Volume above sea level -	1.9	MCY		1.9	MCY	
Wetland Site Volume -	8.3	MCY		8.3	MCY	
Wetland Site Capacity -	11.5	MCY		11.5	MCY	
Total Baseline Area -	1,586	Acres		1,586	Acres	
Total Baseline Perimeter -	44,497	LF		44,497	LF	
Total Interior Dike -	17,624	LF		17,624	LF	
Total Volume -	39.0	MCY		26.2	MCY	
Total Site Capacity -	57.2	MCY		37.5	MCY	

	Alignment No. 3 (20 ft)			Alignment No. 3 (10 ft)		
QUANTITIES	LF	CY/LF	CY	LF	CY/LF	CY
Hydraulic Fill Material						
Unsuitable Backfill -			1,118,000			1,118,000
Wetland Perimeter Dike Section 1A to +11.5 -	2,705	56.5	153,000	2,705	56.5	153,000
Upland Perimeter Dike Section 1B to +11.5 -				4,657	53.2	248,000
Upland Perimeter Dike Section 1B to +20 -	4,657	103.1	480,000			
Wetland Perimeter Dike Section 2A to +11 -	1,416	32.1	45,000	1,416	32.1	45,000
Upland Perimeter Dike Section 2B to +11 -				1,478	38.7	57,000
Upland Perimeter Dike Section 2B to +20 -	1,478	87.8	130,000			
Upland Perimeter Dike Section 5 to +10 -				15,275	42.6	651,000
Upland Perimeter Dike Section 5 to +20 -	15,275	98.5	1,505,000			
Wetland Perimeter Dike Section 6A to +8 -	3,763	38.2	144,000	3,763	38.2	144,000
Wetland Perimeter Dike Section 6B to +8 -	3,670	21.3	78,000	3,670	21.3	78,000
Wetland Perimeter Dike Section 7 to +8 -	11,535	33.1	381,000	11,535	33.1	381,000
Interior Dike Section 8 to +10 -				17,624	39.9	703,000
Interior Dike Section 8 to +20 -	17,624	94.2	1,660,000			
Total -	**62,121**		**5,694,000**	**62,121**		**3,576,000**
	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Perimeter Dike Stone Work						
Slope Armor Dike Section 1A & 1B -	7,361	14.0	103,000	7,361	14.0	103,000
Underlayer Dike Section 1A & 1B -	7,361	6.0	44,000	7,361	6.0	44,000
Toe Armor Dike Section 1A -	2,705	7.1	19,000	2,705	7.1	19,000
Quarry Run Dike Section 1A -	2,705	4.0	11,000	2,705	4.0	11,000
Toe Armor Dike Section 1B -	4,657	6.7	31,000	4,657	6.7	31,000
Quarry Run Dike Section 1B -	4,657	2.9	14,000	4,657	2.9	14,000
Slope Armor Dike Section 2A & 2B -	2,894	12.4	36,000	2,894	12.4	36,000
Underlayer Dike Section 2A & 2B -	2,894	5.8	17,000	2,894	5.8	17,000
Toe Armor Dike Section 2A -	1,416	5.8	8,000	1,416	5.8	8,000
Quarry Run Dike Section 2A -	1,416	2.8	4,000	1,416	2.8	4,000
Toe Armor Dike Section 2B -	1,416	5.9	8,000	1,416	5.9	8,000
Quarry Run Dike Section 2B -	1,416	3.0	4,000	1,416	3.0	4,000
Slope Armor Dike Section 5 -	15,275	9.5	145,000	15,275	9.5	145,000
Underlayer Dike Section 5 -	15,275	4.0	61,000	15,275	4.0	61,000
Toe Armor Dike Section 5 -	15,275	3.8	58,000	15,275	3.8	58,000
Quarry Run Dike Section 5 -	15,275	1.6	25,000	15,275	1.6	25,000
Slope Armor Dike Section 6A -	3,763	5.2	20,000	3,763	5.2	20,000
Underlayer Dike Section 6A -	3,763	2.1	8,000	3,763	2.1	8,000
Toe Armor Dike Section 6A -	3,763	3.4	13,000	3,763	3.4	13,000
Quarry Run Dike Section 6A -	3,763	6.6	25,000	3,763	6.6	25,000
Slope Armor Dike Section 6B -	3,670	5.0	18,000	3,670	5.0	18,000
Underlayer Dike Section 6B -	3,670	2.0	7,000	3,670	2.0	7,000
Toe Armor Dike Section 6B -	3,670	2.5	9,000	3,670	2.5	9,000
Quarry Run Dike Section 6B -	3,670	1.7	6,000	3,670	1.7	6,000
Total -	**32,962**		**694,000**	**32,962**		**694,000**
	LF	SY/LF	SY	LF	SY/LF	SY
Miscellaneous						
Road Stone -	62,121	1.1	68,000	62,121	1.1	68,000
Perimeter Geotextile -	44,497	14.5	645,000	44,497	14.5	645,000
Roadway Geotextile -	62,121	2.6	162,000	62,121	2.6	162,000

James Island Habitat Development

Table D-4 - Preliminary Site Characteristics and Quantities Alignment No. 4

	Alignment No. 4 (20 ft)			Alignment No. 4 (10 ft)		
SITE CHARACTERISTICS						
Uplend Baseline Area -	1,101	Acres		1,101	Acres	
Uplend Baseline Perimeter -	44,742	LF		44,742	LF	
Uplend Site Volume below see level -	10.7	MCY		10.7	MCY	
Uplend Site Volume above sea level -	32.0	MCY		14.2	MCY	
Uplend Site Volume -	42.6	MCY		24.9	MCY	
Uplend Site Capecity -	63.4	MCY		36.1	MCY	
Wetland Baseline Area -	1,101	Acres		1,101	Acres	
Wetlend Beseline Perimeter -	43,486	LF		43,486	LF	
Wettend Site Volume below sea level -	8.4	MCY		8.4	MCY	
Wetland Site Volume above sea level -	2.7	MCY		2.7	MCY	
Wetlend Site Volume -	11.1	MCY		11.1	MCY	
Wetlend Site Capacity -	15.3	MCY		15.3	MCY	
Total Baseline Aree -	2,202	Acres		2,202	Acres	
Total Baseline Perimeter -	48,963	LF		48,963	LF	
Total Interior Dike -	19,632	LF		19,632	LF	
Totel Volume -	53.7	MCY		36.0	MCY	
Totel Site Cepecity -	78.7	MCY		51.4	MCY	
	Alignment No. 4 (20 ft)			**Alignment No. 4 (10 ft)**		
QUANTITIES	LF	CY/LF	CY	LF	CY/LF	CY
Hydraulic Fill Material						
Unsuiteble Beckfill -			263,000			263,000
Wetlend Perimeter Dike Section 1A to +11.5 -	1,975	59.2	117,000	1,975	59.2	117,000
Upland Perimeter Dike Section 1B to +11.5 -				9,004	54.9	494,000
Uplend Perimeter Dike Section 1B to +20 -	9,004	105.0	946,000			
Wetland Perimeter Dike Section 2A to +11 -	2,083	36.4	76,000	2,083	36.4	76,000
Upland Perimeter Dike Section 2B to +11 -				1,825	41.1	75,000
Upland Perimeter Dike Section 2B to +20 -	1,825	91.0	166,000			
Upland Perimeter Dike Section 3 to +10.5 -				14,280	45.4	648,000
Upland Perimeter Dike Section 3 to +20 -	14,280	99.5	1,420,000			
Wetland Perimeter Dike Section 6A to +8 -	3,028	36.9	112,000	3,028	36.9	112,000
Wetland Perimeter Dike Section 6B to +8 -	4,450	21.3	95,000	4,450	21.3	95,000
Wetlend Perimeter Dike Section 7 to +8 -	12,318	30.1	371,000	12,318	30.1	371,000
Interior Dike Section 8 to +10 -				19,632	42.5	835,000
Interior Dike Section 8 to +20 -	19,632	98.1	1,927,000			
Total -	**68,595**		**5,493,000**	**68,595**		**3,086,000**
	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Perimeter Dike Stone Work						
Slope Armor Dike Section 1A & 1B -	10,979	14.0	154,000	10,979	14.0	154,000
Underlayer Dike Section 1A & 1B -	10,979	6.0	66,000	10,979	6.0	66,000
Toe Armor Dike Section 1A -	1,975	7.4	15,000	1,975	7.4	15,000
Quarry Run Dike Section 1A -	1,975	4.8	9,000	1,975	4.8	9,000
Toe Armor Dike Section 1B -	9,004	6.9	62,000	9,004	6.9	82,000
Quarry Run Dike Section 1B -	9,004	3.4	31,000	9,004	3.4	31,000
Slope Armor Dike Section 2A & 2B -	3,908	12.4	48,000	3,908	12.4	48,000
Underlayer Dike Section 2A & 2B -	3,908	5.8	23,000	3,908	5.8	23,000
Toe Armor Dike Section 2A -	2,083	5.8	12,000	2,083	5.8	12,000
Querry Run Dike Section 2A -	2,083	2.8	6,000	2,083	2.8	6,000
Toe Armor Dike Section 2B -	1,825	5.9	11,000	1,825	5.9	11,000
Querry Run Dike Section 2B -	1,825	3.0	5,000	1,825	3.0	5,000
Slope Armor Dike Section 3 -	14,280	9.9	141,000	14,280	9.9	141,000
Underlayer Dike Section 3 -	14,280	4.7	66,000	14,280	4.7	66,000
Toe Armor Dike Section 3 -	14,280	5.4	77,000	14,280	5.4	77,000
Querry Run Dike Section 3 -	14,280	2.3	33,000	14,280	2.3	33,000
Slope Armor Dike Section 6A -	3,028	5.2	16,000	3,028	5.2	16,000
Underleyer Dike Section 6A -	3,028	2.1	6,000	3,028	2.1	6,000
Toe Armor Dike Section 6A -	3,028	3.3	10,000	3,028	3.3	10,000
Quarry Run Dike Section 6A -	3,028	6.1	18,000	3,028	6.1	18,000
Stope Armor Dike Section 6B -	4,450	5.2	23,000	4,450	5.2	23,000
Underleyer Dike Section 6B -	4,450	2.1	9,000	4,450	2.1	9,000
Toe Armor Dike Section 6B -	4,450	2.5	11,000	4,450	2.5	11,000
Querry Run Dike Section 6B -	4,450	1.7	8,000	4,450	1.7	8,000
Total -	**36,645**		**860,000**	**38,645**		**860,000**
	LF	SY/LF	SY	LF	SY/LF	SY
Miscellaneous						
Road Stone -	68,595	1.1	75,000	68,595	1.1	75,000
Perimeter Geotextile -	48,963	14.5	710,000	48,963	14.5	710,000
Roadwey Geotextile -	68,595	2.6	178,000	68,595	2.6	178,000

James Island Habitat Development

Table D-5 - Preliminary Site Characteristics and Quantities Alignment No. 5

SITE CHARACTERISTICS	Alignment No. 5 (20 ft)		Alignment No. 5 (10 ft)	
Upland Baseline Area -	1,036	Acres	1,036	Acres
Upland Baseline Perimeter -	43,595	LF	43,595	LF
Upland Site Volume below sea level -	10.0	MCY	10.0	MCY
Upland Site Volume above sea level -	30.1	MCY	13.4	MCY
Upland Site Volume -	40.1	MCY	23.4	MCY
Upland Site Capacity -	59.7	MCY	34.0	MCY
Wetland Baseline Area -	1,036	Acres	1,036	Acres
Wetland Baseline Perimeter -	39,053	LF	39,053	LF
Wetland Site Volume below sea level -	8.4	MCY	8.4	MCY
Wetland Site Volume above sea level -	2.5	MCY	2.5	MCY
Wetland Site Volume -	10.9	MCY	10.9	MCY
Wetland Site Capacity -	15.0	MCY	15.0	MCY
Total Baseline Area -	2,072	Acres	2,072	Acres
Total Baseline Perimeter -	45,587	LF	45,587	LF
Total Interior Dike -	18,530	LF	18,530	LF
Total Volume -	51.0	MCY	34.3	MCY
Total Site Capacity -	74.7	MCY	49.0	MCY

	Alignment No. 5 (20 ft)			Alignment No. 5 (10 ft)		
QUANTITIES	LF	CY/LF	CY	LF	CY/LF	CY
Hydraulic Fill Material						
Unsuitable Backfill -			263,000			263,000
Wetland Perimeter Dike Section 1A to +11.5 -	1,982	80.7	160,000	1,982	59.2	117,000
Upland Perimeter Dike Section 1B to +11.5 -				9,177	54.9	503,000
Upland Perimeter Dike Section 1B to +20 -	9,177	125.7	1,154,000			
Wetland Perimeter Dike Section 2A to +11 -	1,901	43.5	83,000	1,901	30.0	57,000
Upland Perimeter Dike Section 2B to +11 -				1,785	38.7	69,000
Upland Perimeter Dike Section 2B to +20 -	1,785	103.9	185,000			
Upland Perimeter Dike Section 3 to +10.5 -				14,102	44.4	628,000
Upland Perimeter Dike Section 3 to +20 -	14,102	113.3	1,597,000			
Wetland Perimeter Dike Section 6A to +8 -	3,464	36.1	125,000	3,464	36.1	125,000
Wetland Perimeter Dike Section 6B to +8 -	1,236	20.6	26,000	1,236	20.6	26,000
Wetland Perimeter Dike Section 7 to +8 -	11,939	33.1	395,000	11,939	33.1	395,000
Interior Dike Section 8 to +10 -				18,530	43.9	813,000
Interior Dike Section 8 to +20 -	18,530	100.1	1,856,000			
Total -	**64,117**		**5,844,000**	**64,117**		**2,994,000**
	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Perimeter Dike Stone Work						
Slope Armor Dike Section 1A& 1B -	11,159	14.0	157,000	11,159	14.0	157,000
Underlayer Dike Section 1A & 1B -	11,159	6.0	87,000	11,159	8.0	67,000
Toe Armor Dike Section 1A -	1,982	7.4	15,000	1,982	7.4	15,000
Quarry Run Dike Section 1A -	1,982	4.8	9,000	1,982	4.8	9,000
Toe Armor Dike Section 1B -	9,177	6.9	63,000	9,177	6.9	63,000
Quarry Run Dike Section 1B -	9,177	3.4	31,000	9,177	3.4	31,000
Slope Armor Dike Section 2A & 2B -	3,687	12.4	46,000	3,687	12.4	46,000
Underlayer Dike Section 2A & 2B -	3,687	5.8	21,000	3,687	5.8	21,000
Toe Armor Dike Section 2A -	1,901	5.8	11,000	1,901	5.8	11,000
Quarry Run Dike Section 2A -	1,901	2.8	5,000	1,901	2.8	5,000
Toe Armor Dike Section 2B -	1,785	5.9	10,000	1,785	5.9	10,000
Quarry Run Dike Section 2B -	1,785	3.0	5,000	1,785	3.0	5,000
Slope Armor Dike Section 3 -	14,102	9.9	140,000	14,102	9.9	140,000
Underlayer Dike Section 3 -	14,102	4.7	66,000	14,102	4.7	66,000
Toe Armor Dike Section 3 -	14,102	5.3	74,000	14,102	5.3	74,000
Quarry Run Dike Section 3 -	14,102	2.1	29,000	14,102	2.1	29,000
Slope Armor Dike Section 6A -	3,464	5.2	18,000	3,464	5.2	18,000
Underlayer Dike Section 6A -	3,464	2.1	7,000	3,464	2.1	7,000
Toe Armor Dike Section 6A -	3,464	3.2	11,000	3,464	3.2	11,000
Quarry Run Dike Section 6A -	3,464	5.7	20,000	3,464	5.7	20,000
Slope Armor Dike Section 6B -	1,236	5.2	6,000	1,236	5.2	6,000
Underlayer Dike Section 6B -	1,236	2.1	3,000	1,236	2.1	3,000
Toe Armor Dike Section 6B -	1,236	2.5	3,000	1,236	2.5	3,000
Quarry Run Dike Section 6B -	1,236	1.7	2,000	1,236	1.7	2,000
Total -	**33,648**		**819,000**	**33,648**		**819,000**
	LF	SY/LF	SY	LF	SY/LF	SY
Miscellaneous						
Road Stone -	64,117	1.1	71,000	64,117	1.1	71,000
Perimeter Geotextile -	45,587	14.5	661,000	45,587	14.5	661,000
Roadway Geotextile -	64,117	2.8	187,000	64,117	2.6	167,000

APPENDIX E

COST TABLES

James Island Habitat Development

Table E-1 - Preliminary Construction Costs Alignment No. 1
(Costs are Estimated in 2002 Dollars)

	Unit	Unit Rate $	Alignment No. 1 (20 FT) Qty	Alignment No. 1 (20 FT) Cost $	Alignment No. 1 (10 FT) Qty	Alignment No. 1 (10 FT) Cost $
Mobilization/Demobilization & Bonds	L.S.	4,800,000	Job	4,800,000	Job	4,800,000
Road Stone	S.Y.	12.00	50,000	600,000	50,000	600,000
Geotextile	S.Y.	4.00	582,000	2,328,000	582,000	2,328,000
Personnel Pier	L.S.	250,000	Job	250,000	Job	250,000
Unsuitable Foundation Excavation	C.Y.	12.00	1,118,000	13,416,000	976,000	11,712,000
Stone Work						
Slope Armor Dike Section	Ton	42.00	217,000	9,114,000	217,000	9,114,000
Underlayer Dike Section	Ton	41.00	99,000	4,059,000	99,000	4,059,000
Toe Armor Dike Section	Ton	53.00	96,000	5,088,000	96,000	5,088,000
Quarry Run Dike Section	Ton	40.00	43,000	1,720,000	43,000	1,720,000
Spillways	Each	250,000	6	1,500,000	6	1,500,000
Nursery Planting	L.S.	200,000	Job	200,000	Job	200,000
SUBTOTAL				43,075,000		41,371,000
Borrow Alternative 1 (offsite)						
Clam Shell Dredge from Craighill Channel	C.Y.	2.25	4,505,000	10,136,000	2,733,000	6,149,000
40 Miles One Way Barge Transport	C.Y.	4.00	4,505,000	18,020,000	2,733,000	10,932,000
Dike Fill Hydraulically from Barge	C.Y.	7.00	4,505,000	31,535,000	2,733,000	19,131,000
A1 GRAND TOTAL				**102,766,000**		**77,583,000**
$ per CY of Site Capacity				2.96		3.43
Borrow Alternative 2 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	8.00	4,505,000	36,040,000	2,733,000	21,864,000
A2 GRAND TOTAL				**79,115,000**		**63,235,000**
$ per CY of Site Capacity				2.28		2.80

James Island Habitat Development

Table E-2 - Preliminary Construction Costs Alignment No. 2
(Costs are Estimated in 2002 Dollars)

	Unit	Unit	Alignment No. 2 (20 FT)		Alignment No. 2 (10 FT)	
		Rate $	Qty	Cost $	Qty	Cost $
Mobilization/Demobilization & Bonds	L.S.	4,800,000	Job	4,800,000	Job	4,800,000
Road Stone	S.Y.	12.00	74,000	888,000	74,000	888,000
Geotextile	S.Y.	4.00	882,000	3,528,000	882,000	3,528,000
Personnel Pier	L.S.	250,000	Job	250,000	Job	250,000
Unsuitable Foundation Excavation	C.Y.	12.00	360,000	4,320,000	360,000	4,320,000
Stone Work						
Slope Armor Dike Section	Ton	42.00	393,000	16,506,000	393,000	16,506,000
Underlayer Dike Section	Ton	41.00	173,000	7,093,000	173,000	7,093,000
Toe Armor Dike Section	Ton	53.00	200,000	10,600,000	200,000	10,600,000
Quarry Run Dike Section	Ton	40.00	106,000	4,240,000	106,000	4,240,000
Spillways	Each	250,000	10	2,500,000	10	2,500,000
Nursery Planting	L.S.	200,000	Job	200,000	Job	200,000
SUBTOTAL				54,925,000		54,925,000
Borrow Alternative 1 (offsite)						
Clam Shell Dredge from Craighill Channel	C.Y.	2.25	5,437,000	12,233,000	3,149,000	7,085,000
40 Miles One Way Barge Transport	C.Y.	4.00	5,437,000	21,748,000	3,149,000	12,596,000
Dike Fill Hydraulically from Barge	C.Y.	7.00	5,437,000	38,059,000	3,149,000	22,043,000
A1 GRAND TOTAL				**126,965,000**		**96,649,000**
$ per CY of Site Capacity				1.62		1.86
Borrow Alternative 2 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	8.00	5,437,000	43,496,000	3,149,000	25,192,000
A2 GRAND TOTAL				**98,421,000**		**80,117,000**
$ per CY of Site Capacity				1.26		1.54

James Island Habitat Development

Table E-3 - Preliminary Construction Costs Alignment No. 3 (Costs are Estimated In 2002 Dollars)

	Unit	Unit Rate $	Alignment No. 3 (20 FT) Qty	Alignment No. 3 (20 FT) Cost $	Alignment No. 3 (10 FT) Qty	Alignment No. 3 (10 FT) Cost $
Mobilization/Demobilization & Bonds	L.S.	4,800,000	Job	4,800,000	Job	4,800,000
Road Stone	S.Y.	12.00	68,000	816,000	68,000	816,000
Geotextile	S.Y.	4.00	807,000	3,228,000	807,000	3,228,000
Personnel Pier	L.S.	250,000	Job	250,000	Job	250,000
Unsuitable Foundation Excavation	C.Y.	12.00	1,118,000	13,416,000	1,118,000	13,416,000
Stone Work						
Slope Armor Dike Section 5	Ton	42.00	322,000	13,524,000	322,000	13,524,000
Underlayer Dike Section 5	Ton	41.00	137,000	5,617,000	137,000	5,617,000
Toe Armor Dike Section 5	Ton	40.00	146,000	5,840,000	146,000	5,840,000
Quarry Run Dike Section 5	Ton	40.00	89,000	3,560,000	89,000	3,560,000
Spillways	Each	250,000	10	2,500,000	10	2,500,000
Nursery Planting	L.S.	200,000	Job	200,000	Job	200,000
SUBTOTAL				53,751,000		53,751,000
Borrow Alternative 1 (offsite)						
Clam Shell Dredge from Craighill Channel	C.Y.	2.25	5,694,000	12,812,000	3,578,000	8,051,000
40 Miles One Way Barge Transport	C.Y.	4.00	5,694,000	22,776,000	3,578,000	14,312,000
Dike Fill Hydraulically from Barge	C.Y.	7.00	5,694,000	39,858,000	3,578,000	25,046,000
A1 GRAND TOTAL				**129,197,000**		**101,160,000**
$ per CY of Site Capacity				2.26		2.70
Borrow Alternative 2 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	8.00	5,694,000	45,552,000	3,578,000	28,624,000
A2 GRAND TOTAL				**99,303,000**		**82,375,000**
$ per CY of Site Capacity				1.74		2.20

James Island Habitat Development

Table E-4 - Preliminary Construction Costs Alignment No. 4
(Costs are Estimated in 2002 Dollars)

	Unit	Unit Rate $	Alignment No. 4 (20 FT) Qty	Alignment No. 4 (20 FT) Cost $	Alignment No. 4 (10 FT) Qty	Alignment No. 4 (10 FT) Cost $
Mobilization/Demobilization & Bonds	L.S.	4,800,000	Job	4,800,000	Job	4,800,000
Road Stone	S.Y.	12.00	75,000	900,000	75,000	900,000
Geotextile	S.Y.	4.00	888,000	3,552,000	888,000	3,552,000
Personnel Pier	L.S.	250,000	Job	250,000	Job	250,000
Unsuitable Foundation Excavation	C.Y.	12.00	263,000	3,156,000	263,000	3,156,000
Stone Work						
Slope Armor Dike Section	Ton	42.00	382,000	16,044,000	382,000	16,044,000
Underlayer Dike Section	Ton	41.00	170,000	6,970,000	170,000	6,970,000
Toe Armor Dike Section	Ton	53.00	198,000	10,494,000	198,000	10,494,000
Quarry Run Dike Section	Ton	40.00	110,000	4,400,000	110,000	4,400,000
Spillways	Each	250,000	10	2,500,000	10	2,500,000
Nursery Planting	L.S.	200,000	Job	200,000	Job	200,000
SUBTOTAL				53,266,000		53,266,000
Borrow Alternative 1 (offsite)						
Clam Shell Dredge from Craighill Channel	C.Y.	2.25	5,493,000	12,359,000	3,086,000	6,944,000
40 Miles One Way Barge Transport	C.Y.	4.00	5,493,000	21,972,000	3,086,000	12,344,000
Dike Fill Hydraulically from Barge	C.Y.	7.00	5,493,000	38,451,000	3,086,000	21,602,000
A1 GRAND TOTAL				**126,048,000**		**94,156,000**
$ per CY of Site Capacity				1.60		1.83
Borrow Alternative 2 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	8.00	5,493,000	43,944,000	3,086,000	24,688,000
A2 GRAND TOTAL				**97,210,000**		**77,954,000**
$ per CY of Site Capacity				1.23		1.52

James Island Habitat Development

Table E-5 - Preliminary Construction Costs Alignment No. 5
(Costs are Estimated in 2002 Dollars)

	Unit	Unit Rate $	Alignment No. 5 (20 FT) Qty	Alignment No. 5 (20 FT) Cost $	Alignment No. 5 (10 FT) Qty	Alignment No. 5 (10 FT) Cost $
Mobilization/Demobilization & Bonds	L.S.	4,800,000	Job	4,800,000	Job	4,800,000
Road Stone	S.Y.	12.00	71,000	852,000	71,000	852,000
Geotextile	S.Y.	4.00	828,000	3,312,000	828,000	3,312,000
Personnel Pier	L.S.	250,000	Job	250,000	Job	250,000
Unsuitable Foundation Excavation	C.Y.	12.00	263,000	3,156,000	263,000	3,156,000
Stone Work						
Slope Armor Dike Section 3	Ton	42.00	367,000	15,414,000	367,000	15,414,000
Underlayer Dike Section 3	Ton	41.00	164,000	6,724,000	164,000	6,724,000
Toe Armor Dike Section 3	Ton	53.00	187,000	9,911,000	187,000	9,911,000
Quarry Run Dike Section 3	Ton	40.00	101,000	4,040,000	101,000	4,040,000
Spillways	Each	250,000	10	2,500,000	10	2,500,000
Nursery Planting	L.S.	200,000	Job	200,000	Job	200,000
SUBTOTAL				51,159,000		51,159,000
Borrow Alternative 1 (offsite)						
Clam Shell Dredge from Craighill Channel	C.Y.	2.25	5,844,000	13,149,000	2,994,000	6,737,000
40 Miles One Way Barge Transport	C.Y.	4.00	5,844,000	23,376,000	2,994,000	11,976,000
Dike Fill Hydraulically from Barge	C.Y.	7.00	5,844,000	40,908,000	2,994,000	20,958,000
A1 GRAND TOTAL				**128,592,000**		**90,830,000**
$ per CY of Site Capacity				1.72		1.86
Borrow Alternative 2 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	8.00	5,844,000	46,752,000	2,994,000	23,952,000
A2 GRAND TOTAL				**97,911,000**		**75,111,000**
$ per CY of Site Capacity				1.31		1.53

James Island Habitat Development

Table E - 6 Project Cost Analysis for Dike Alignment No. 1 (10 ft)
(Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	22.6	978.6	Site Surface Area (Ac)
Site Operating Life (Years)	13.3	32,102	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	1.7	13,039	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	10	Final Dike Elev. (Ft)

	Quantity	Unit	Unit Cost $	Item Cost $	Comments
A. Initial Construction Costs:					
Initial Construction Costs				63,235,000	From Table E-1 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**66,235,000**	
B. Site Development Costs:					
Dredged Material Management	13.3	Year	1,104,000	14,683,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	15.3	Year	1,535,000	23,486,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	16.3	Year	675,000	11,003,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**49,172,000**	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	13.3	Year	500,000	6,650,000	
Implementation					
Channels	489	Acre	6,000	2,936,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	979	Acre	4,400	4,306,000	$4,400 per acre
Operation & Maintenance	13.3	Year	500,000	6,650,000	
Total Habitat Development Costs			$	**23,542,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	14.0	Year	2,000,000	28,000,000	Mob & Demob for operating life of site
Dredging	22.6	Mcy	2.00	45,200,000	Clamshell Dredging
Transport	22.6	Mcy	4.00	90,400,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	22.6	Mcy	2.25	50,850,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**214,450,000**	
Subtotal Project Cost A+B+C+D			$	**353,399,000**	
Contingency @	15%			53,010,000	
Total Project Cost A+B+C+D			$	**406,409,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**18.00**	**per cubic yard**

Apportioned Costs to Channel Projects:

	Quantity	Unit	Unit Cost $	Item Cost $
Dredging, Transport & Placement	22.6	Mcy	3.80	85,880,000
Contingency @	15%			12,882,000
Total Apportioned Costs to Channel Projects			$	**98,762,000**

Summary of Costs:

Total Project Project Cost		406,409,000
Less Apportioned Cost to Channel Projects		(98,762,000)
Total Apportioned Cost to James Island Project	$	**307,647,000**

James Island Habitat Development

Table E - 7 Project Cost Analysis for Dike Alignment No. 2 (10 ft)
(Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	52.0	2,126.8	Site Surface Area (Ac)
Site Operating Life (Years)	14.9	48,812	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	3.5	18,159	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	10	Final Dike Elev. (Ft)

	Quantity	*Unit*	*Unit Cost $*	*Item Cost $*	*Comments*
A. Initial Construction Costs:					
Initial Construction Costs				80,117,000	From Table E-2 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**83,117,000**	
B. Site Development Costs:					
Dredged Material Management	14.9	Year	2,224,000	33,138,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	16.9	Year	2,287,000	38,650,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	17.9	Year	675,000	12,083,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**83,871,000**	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	14.9	Year	500,000	7,450,000	
Implementation					
Channels	1,063	Acre	6,000	6,380,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	2,127	Acre	4,400	9,358,000	$4,400 per acre
Operation & Maintenance	14.9	Year	500,000	7,450,000	
Total Habitat Development Costs			$	**33,638,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	15.0	Year	2,000,000	30,000,000	Mob & Demob for operating life of site
Dredging	52.0	Mcy	2.00	104,000,000	Clamshell Dredging
Transport	52.0	Mcy	4.00	208,000,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	52.0	Mcy	2.25	117,000,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**459,000,000**	
Subtotal Project Cost A+B+C+D			$	**659,626,000**	
Contingency @	15%			98,944,000	
Total Project Cost A+B+C+D			$	**758,570,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**15.00**	**per cubic yard**
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	52.0	Mcy	3.80	197,600,000	
Contingency @	15%			29,640,000	
Total Apportioned Costs to Channel Projects			$	**227,240,000**	
Summary of Costs:					
Total Project Project Cost				758,570,000	
Less Apportioned Cost to Channel Projects				(227,240,000)	
Total Apportioned Cost to James Island Project			$	**531,330,000**	

James Island Habitat Development

Table E - 8 Project Cost Analysis for Dike Alignment No. 3 (10 ft) (Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	37.5	1,586.0	Site Surface Area (Ac)
Site Operating Life (Years)	13.4	44,497	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	2.8	17,624	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	10	Final Dike Elev. (Ft)

	Quantity	Unit	Unit Cost $	Item Cost $	Comments
A. Initial Construction Costs:					
Initial Construction Costs				82,375,000	From Table E-3 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	85,375,000	
B. Site Development Costs:					
Dredged Material Management	13.4	Year	1,696,000	22,726,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	15.4	Year	2,092,000	32,217,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	16.4	Year	675,000	11,070,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	66,013,000	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	13.4	Year	500,000	6,700,000	
Implementation					
Channels	793	Acre	6,000	4,758,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	1,586	Acre	4,400	6,978,000	$4,400 per acre
Operation & Maintenance	13.4	Year	500,000	6,700,000	
Total Habitat Development Costs			$	28,136,000	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	14.0	Year	2,000,000	28,000,000	Mob & Demob for operating life of site
Dredging	37.5	Mcy	2.00	75,000,000	Clamshell Dredging
Transport	37.5	Mcy	4.00	150,000,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	37.5	Mcy	2.25	84,375,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	337,375,000	
Subtotal Project Cost A+B+C+D			$	516,899,000	
Contingency @	15%			77,535,000	
Total Project Cost A+B+C+D			$	594,434,000	
Total Unit Cost per CY Capacity (Rounded)			$	16.00	per cubic yard
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	37.5	Mcy	3.80	142,500,000	
Contingency @	15%			21,375,000	
Total Apportioned Costs to Channel Projects			$	163,875,000	
Summary of Costs:					
Total Project Project Cost				594,434,000	
Less Apportioned Cost to Channel Projects				(163,875,000)	
Total Apportioned Cost to James Island Project			$	430,559,000	

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Table E - 9 Project Cost Analysis for Dike Alignment No. 4 (10 ft) (Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	51.4	2,202.0	Site Surface Area (Ac)
Site Operating Life (Years)	14.7	48,963	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	3.5	19,632	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	10	Final Dike Elev. (Ft)

	Quantity	*Unit*	*Unit Cost $*	*Item Cost $*	*Comments*
A. Initial Construction Costs:					
Initial Construction Costs				77,954,000	From Table E-4 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	80,954,000	
B. Site Development Costs:					
Dredged Material Management	14.7	Year	2,297,000	33,766,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	16.7	Year	2,293,000	38,293,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	17.7	Year	675,000	11,948,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	84,007,000	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	14.7	Year	500,000	7,350,000	
Implementation					
Channels	1,101	Acre	6,000	6,606,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	2,202	Acre	4,400	9,689,000	$4,400 per acre
Operation & Maintenance	14.7	Year	500,000	7,350,000	
Total Habitat Development Costs			$	33,995,000	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	15.0	Year	2,000,000	30,000,000	Mob & Demob for operating life of site
Dredging	51.4	Mcy	2.00	102,800,000	Clamshell Dredging
Transport	51.4	Mcy	4.00	205,600,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	51.4	Mcy	2.25	115,650,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	454,050,000	
Subtotal Project Cost A+B+C+D			$	653,006,000	
Contingency @	15%			97,951,000	
Total Project Cost A+B+C+D			$	750,957,000	
Total Unit Cost per CY Capacity (Rounded)			$	15.00	per cubic yard
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	51.4	Mcy	3.80	195,320,000	
Contingency @	15%			29,298,000	
Total Apportioned Costs to Channel Projects			$	224,618,000	
Summary of Costs:					
Total Project Project Cost				750,957,000	
Less Apportioned Cost to Channel Projects				(224,618,000)	
Total Apportioned Cost to James Island Project			$	526,339,000	

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Table E - 10 Project Cost Analysis for Dike Alignment No. 5 (10 ft) (Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	49.0	2,072.0	Site Surface Area (Ac)
Site Operating Life (Years)	13.6	45,587	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	3.6	18,630	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	10	Final Dike Elev. (Ft)

	Quantity	Unit	Unit Cost $	Item Cost $	Comments
A. Initial Construction Costs:					
Initial Construction Costs				75,111,000	From Table E-5 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**78,111,000**	
B. Site Development Costs:					
Dredged Material Management	13.6	Year	2,170,000	29,512,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	15.6	Year	2,141,000	33,400,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	16.6	Year	675,000	11,205,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**74,117,000**	
C. Habitat Development Cost:					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	13.6	Year	500,000	6,800,000	
Implementation					
Channels	1,036	Acre	6,000	6,216,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	2,072	Acre	4,400	9,117,000	$4,400 per acre
Operation & Maintenance	13.6	Year	500,000	6,800,000	
Total Habitat Development Costs			$	**31,933,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	14.0	Year	2,000,000	28,000,000	Mob & Demob for operating life of site
Dredging	49.0	Mcy	2.00	98,000,000	Clamshell Dredging
Transport	49.0	Mcy	4.00	196,000,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	49.0	Mcy	2.25	110,250,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**432,250,000**	
Subtotal Project Cost A+B+C+D			$	**616,411,000**	
Contingency @	15%			92,462,000	
Total Project Cost A+B+C+D			$	**708,873,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**14.00**	**per cubic yard**
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	49.0	Mcy	3.80	186,200,000	
Contingency @	15%			27,930,000	
Total Apportioned Costs to Channel Projects			$	**214,130,000**	
Summary of Costs:					
Total Project Project Cost				708,873,000	
Less Apportioned Cost to Channel Projects				(214,130,000)	
Total Apportioned Cost to James Island Project			$	**494,743,000**	

James Island Habitat Development

Table E - 11 Project Cost Analysis for Dike Alignment No. 1 (20 ft) (Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	34.7	978.6	Site Surface Area (Ac)
Site Operating Life (Years)	20.4	32,102	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	1.7	13,039	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	20	Final Dike Elev. (Ft)

	Quantity	*Unit*	*Unit Cost $*	*Item Cost $*	*Comments*
A. Initial Construction Costs:					
Initial Construction Costs				79,115,000	From Table E-1 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**82,115,000**	
B. Site Development Costs:					
Dredged Material Management	20.4	Year	1,104,000	22,522,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	22.4	Year	1,535,000	34,384,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	23.4	Year	675,000	15,795,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**72,701,000**	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	20 4	Year	500,000	10,200,000	
Implementation					
Channels	489	Acre	6,000	2,936,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	979	Acre	4,400	4,306,000	$4,400 per acre
Operation & Maintenance	20 4	Year	500,000	10,200,000	
Total Habitat Development Costs			$	**30,642,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	21 0	Year	2,000,000	42,000,000	Mob & Demob for operating life of site
Dredging	34 7	Mcy	2 00	69,400,000	Clamshell Dredging
Transport	34 7	Mcy	4 00	138,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	34 7	Mcy	2.25	78,075,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**328,275,000**	
Subtotal Project Cost A+B+C+D			$	**513,733,000**	
Contingency @	15%			77,060,000	
Total Project Cost A+B+C+D			$	**590,793,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**17.00**	per cubic yard
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	34.7	Mcy	3.80	131,860,000	
Contingency @	15%			19,779,000	
Total Apportioned Costs to Channel Projects			$	**151,639,000**	
Summary of Costs:					
Total Project Project Cost				590,793,000	
Less Apportioned Cost to Channel Projects				(151,639,000)	
Total Apportioned Cost to James Island Project			$	**439,154,000**	

James Island Habitat Development

Table E - 12 Project Cost Analysis for Dike Alignment No. 2 (20 ft) (Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	78.3	2,126.8	Site Surface Area (Ac)
Site Operating Life (Years)	22.4	48,812	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	3.5	18,159	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	20	Final Dike Elev. (Ft)

	Quantity	*Unit*	*Unit Cost $*	*Item Cost $*	*Comments*
A. Initial Construction Costs:					
Initial Construction Costs				98,421,000	From Table E-2 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**101,421,000**	
B. Site Development Costs:					
Dredged Material Management	22.4	Year	2,224,000	49,818,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	24.4	Year	2,287,000	55,803,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	25.4	Year	675,000	17,145,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**122,766,000**	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	22.4	Year	500,000	11,200,000	
Implementation					
Channels	1,063	Acre	6,000	6,380,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	2,127	Acre	4,400	9,358,000	$4,400 per acre
Operation & Maintenance	22.4	Year	500,000	11,200,000	
Total Habitat Development Costs			$	**41,138,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	23.0	Year	2,000,000	46,000,000	Mob & Demob for operating life of site
Dredging	78.3	Mcy	2.00	156,600,000	Clamshell Dredging
Transport	78.3	Mcy	4.00	313,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	78.3	Mcy	2.25	176,175,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**691,975,000**	
Subtotal Project Cost A+B+C+D			$	**957,300,000**	
Contingency @	15%			143,595,000	
Total Project Cost A+B+C+D			$	**1,100,895,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**14.00**	**per cubic yard**
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	78.3	Mcy	3.80	297,540,000	
Contingency @	15%			44,631,000	
Total Apportioned Costs to Channel Projects			$	**342,171,000**	
Summary of Costs:					
Total Project Project Cost				1,100,895,000	
Less Apportioned Cost to Channel Projects				(342,171,000)	
Total Apportioned Cost to James Island Project			$	**758,724,000**	

James Island Habitat Development

Table E - 13 Project Cost Analysis for Dike Alignment No. 3 (20 ft) (Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	57.2	1,586.0	Site Surface Area (Ac)
Site Operating Life (Years)	20.4	44,497	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	2.8	17,624	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	20	Final Dike Elev. (Ft)

	Quantity	Unit	Unit Cost $	Item Cost $	Comments
A. Initial Construction Costs:					
Initial Construction Costs				99,303,000	From Table E-3 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**102,303,000**	
B. Site Development Costs:					
Dredged Material Management	20.4	Year	1,696,000	34,598,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	22.4	Year	2,092,000	46,861,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	23.4	Year	675,000	15,795,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**97,254,000**	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	20.4	Year	500,000	10,200,000	
Implementation					
Channels	793	Acre	6,000	4,758,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	1,586	Acre	4,400	6,978,000	$4,400 per acre
Operation & Maintenance	20.4	Year	500,000	10,200,000	
Total Habitat Development Costs			$	**35,136,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	21.0	Year	2,000,000	42,000,000	Mob & Demob for operating life of site
Dredging	57.2	Mcy	2.00	114,400,000	Clamshell Dredging
Transport	57.2	Mcy	4.00	228,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	57.2	Mcy	2.25	128,700,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**513,900,000**	
Subtotal Project Cost A+B+C+D			$	**748,593,000**	
Contingency @	15%			112,289,000	
Total Project Cost A+B+C+D			$	**860,882,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**15.00**	**per cubic yard**
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	57.2	Mcy	3.80	217,360,000	
Contingency @	15%			32,604,000	
Total Apportioned Costs to Channel Projects			$	**249,964,000**	
Summary of Costs:					
Total Project Project Cost				860,882,000	
Less Apportioned Cost to Channel Projects				(249,964,000)	
Total Apportioned Cost to James Island Project			$	**610,918,000**	

James Island Habitat Development

Table E - 14 Project Cost Analysis for Dike Alignment No. 4 (20 ft)
(Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	78.7	2,202.0	Site Surface Area (Ac)
Site Operating Life (Years)	22.5	48,963	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	3.5	19,632	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	20	Final Dike Elev. (Ft)

	Quantity	Unit	Unit Cost $	Item Cost $	Comments
A. Initial Construction Costs:					
Initial Construction Costs				97,210,000	From Table E-4 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**100,210,000**	
B. Site Development Costs:					
Dredged Material Management	22.5	Year	2,297,000	51,683,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	24.5	Year	2,293,000	56,179,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	25.5	Year	675,000	17,213,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**125,075,000**	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	22.5	Year	500,000	11,250,000	
Implementation					
Channels	1,101	Acre	6,000	6,606,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	2,202	Acre	4,400	9,689,000	$4,400 per acre
Operation & Maintenance	22.5	Year	500,000	11,250,000	
Total Habitat Development Costs			$	**41,795,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	23.0	Year	2,000,000	46,000,000	Mob & Demob for operating life of site
Dredging	78.7	Mcy	2.00	157,400,000	Clamshell Dredging
Transport	78.7	Mcy	4.00	314,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	78.7	Mcy	2.25	177,075,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**695,275,000**	
Subtotal Project Cost A+B+C+D			$	**962,355,000**	
Contingency @	15%			144,353,000	
Total Project Cost A+B+C+D			$	**1,106,708,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**14.00**	**per cubic yard**
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	78.7	Mcy	3.80	299,060,000	
Contingency @	15%			44,859,000	
Total Apportioned Costs to Channel Projects			$	**343,919,000**	
Summary of Costs:					
Total Project Project Cost				1,106,708,000	
Less Apportioned Cost to Channel Projects				(343,919,000)	
Total Apportioned Cost to James Island Project			$	**762,789,000**	

James Island Habitat Development

Table E - 15 Project Cost Analysis for Dike Alignment No. 5 (20 ft) (Costs are Estimated in 2002 Dollars)

Basis For Estimate:

Site Capacity (Mcy)	74.7	2,072.0	Site Surface Area (Ac)
Site Operating Life (Years)	21.3	45,587	Site Perimeter Dike (Ft)
Annual Channel (Cut) Volume (Mcy)	3.5	18,530	Site Interior Dikes (Ft)
Average One-Way Haul Distance (NM)	40	20	Final Dike Elev. (Ft)

	Quantity	*Unit*	*Unit Cost $*	*Item Cost $*	*Comments*
A. Initial Construction Costs:					
Initial Construction Costs				97,911,000	From Table E-5 (onsite)
Study Costs				3,000,000	Conceptual, pre-feasibility and feasibility costs.
Total Initial Construction Costs			$	**100,911,000**	
B. Site Development Costs:					
Dredged Material Management	21.3	Year	2,170,000	46,221,000	Placement, dewatering and crust management costs for the operating life. $150,000 + ($975 per acre)
Site Maintenance	23.3	Year	2,141,000	49,885,000	Site Maintenance for operating life plus 2 years following site placement. $90,000 + ($45 per Perimeter Ft.)
Site Monitoring and Reporting	24.3	Year	675,000	16,403,000	Environmental monitoring for operating life, plus 3 years following site placement.
Total Site Development Costs			$	**112,509,000**	
C. Habitat Development Cost :					
Plan and Design	3.0	Year	1,000,000	3,000,000	
Monitoring	21.3	Year	500,000	10,650,000	
Implementation					
Channels	1,036	Acre	6,000	6,216,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting / Seeding	2,072	Acre	4,400	9,117,000	$4,400 per acre
Operation & Maintenance	21.3	Year	500,000	10,650,000	
Total Habitat Development Costs			$	**39,633,000**	
D. Dredging, Transportation & Placement Costs:					
Mob and Demob	22.0	Year	2,000,000	44,000,000	Mob & Demob for operating life of site
Dredging	74.7	Mcy	2.00	149,400,000	Clamshell Dredging
Transport	74.7	Mcy	4.00	298,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	74.7	Mcy	2.25	168,075,000	Hydraulic Unloader
Total Dredging, Transport & Placement Costs			$	**660,275,000**	
Subtotal Project Cost A+B+C+D			$	**913,328,000**	
Contingency @	15%			136,999,000	
Total Project Cost A+B+C+D			$	**1,050,327,000**	
Total Unit Cost per CY Capacity (Rounded)			$	**14.00**	per cubic yard
Apportioned Costs to Channel Projects:					
Dredging, Transport & Placement	74.7	Mcy	3.80	283,860,000	
Contingency @	15%			42,579,000	
Total Apportioned Costs to Channel Projects			$	**326,439,000**	
Summary of Costs:					
Total Project Project Cost				1,050,327,000	
Less Apportioned Cost to Channel Projects				(326,439,000)	
Total Apportioned Cost to James Island Project			$	**723,888,000**	

TABLE E-16 ESCALATION OF UNIT RATES FROM PREVIOUS POPLAR BIDS

(Based on 1998 Poplar Island Phase I and 2000 Poplar Island Phase II Bids - Escalated to 2002 @ 2.5% per annum)

Item No.	Description	Unit	Poplar Island Phase I - Bid Unit Rates From Five Lowest Bidders					Escalated @	Poplar II Escal.	Combined Avg.	Use For
			Low Bid	2nd Bid	3rd Bid	4th Bid	5th Bid	1.104	1.051	Rounded	James Isl.
01	Bonds	LS	400,000.00	300,000.00	225,000.00	500,000.00	356,250.00	393,233.34	188,000.00	291,000.00	300,000.00
02	Mob / Demob	LS	4,870,800.00	4,200,259.00	2,000,000.00	5,948,000.00	4,254,764.75	4,696,464.18	4,203,000.00	4,450,000.00	4,500,000.00
03	Geotechnical Borings	Lin Ft	50.00	75.00	55.00	50.00	57.50	63.47		63.00	63.00
04	Roadway Stone	Sq Yd	10.00	10.00	10.00	16.00	11.50	12.69	11.00	12.00	12.00
05	Geotextile	Sq Yd	3.00	3.50	3.00	4.00	3.38	3.73	4.00	4.00	4.00
06	Personnel Pier	LS	100,000.00	410,400.00	120,000.00	200,000.00	207,600.00	229,151.56		229,000.00	250,000.00
07	Unsuitable Fdn Excavation	CY	8.00	7.50	10.00	10.00	8.88	9.80	14.00	12.00	12.00
08	Hydraulic Fill Material	CY	5.50	5.00	4.00	5.94	5.11	5.64	8.00	7.00	8.00
09AA	2000 # Toe Armor Stone	Ton	36.00	55.00	45.00	48.00	46.00	50.78	53.00	52.00	54.00
09AB	1500 # Toe Armor Stone	Ton	36.00	50.00	45.00	48.00	44.75	49.40	53.00	51.00	53.00
09AC	3000 # Armor Stone	Ton	34.00	35.00	45.00	32.00	36.50	40.29	37.00	39.00	41.00
09AD	4000 # Armor Stone	Ton	34.00	34.00	45.00	32.00	36.25	40.01		40.00	42.00
09AE	Underlayer & 250 # Armor	Ton	32.00	36.00	45.00	37.00	37.50	41.39	37.00	39.00	41.00
09AF	Quarry Run Stone	Ton	26.00	20.00	24.00	25.00	23.75	26.22	49.00	38.00	40.00
09AG	No. 57 Stone	CY	30.00	40.00	60.00	45.00	43.75	48.29		48.00	50.00
10AA	Type A Spillway	Each	100,000.00	90,000.00	175,000.00	95,000.00	115,000.00	126,938.48	158,000.00	142,000.00	250,000.00
10AB	Type B Spillway	Each	200,000.00	200,000.00	360,000.00	175,000.00	233,750.00	258,016.26	315,000.00	287,000.00	250,000.00
10AC	Type C Spillway	Each	225,000.00	210,000.00	400,000.00	200,000.00	258,750.00	285,611.59		286,000.00	250,000.00
11	Nursery Planting	LS	150,000.00	155,000.00	200,000.00	100,000.00	151,250.00	166,951.70		167,000.00	200,000.00
12AA	Geotextile Tubes	LS	700,000.00	800,000.00	900,000.00	1,349,000.00	937,250.00	1,034,548.63		1,035,000.00	
12AB	Geotextile Tubes Dike Sect.	LS	600,000.00	1,300,000.00	1,000,000.00	1,025,000.00	981,250.00	1,083,116.40		1,083,000.00	
13	Geotextile Tubes Shoreline	LS	60,000.00	217,000.00	250,000.00	285,000.00	203,000.00	224,074.02		224,000.00	
14	Shell Clutch	LS	100,000.00	225,120.00	200,000.00	141,630.00	166,687.50	183,991.81	262,000.00	223,000.00	

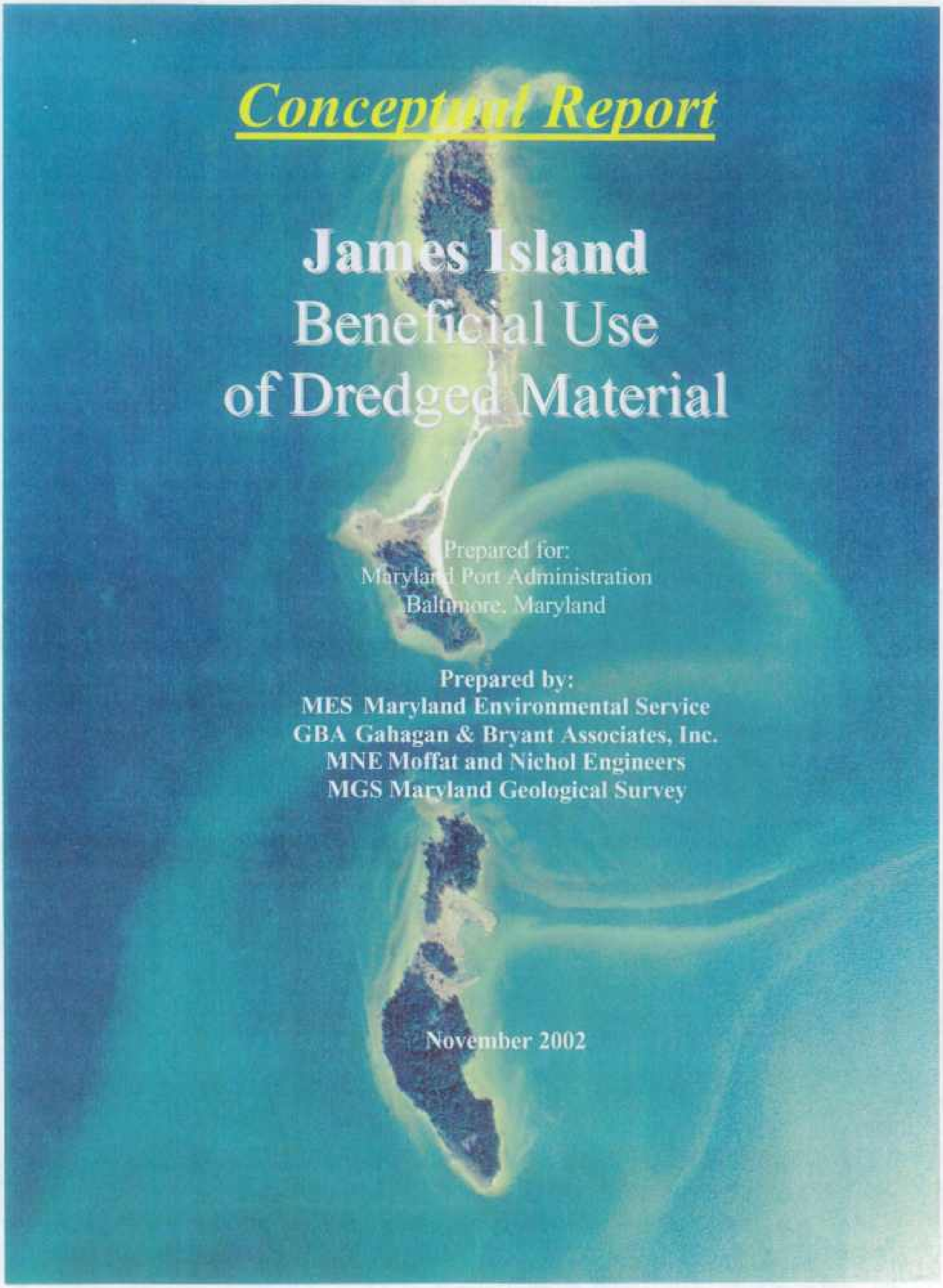
Note: $2.00 added to James Island rock unit rates to account for longer haul distance.

APPENDIX E

Appendix E:

James Island Beneficial Use of Dredge Material Conceptual Report

(Maryland Environmental Service)



Conceptual Report

James Island
Beneficial Use
of Dredged Material

Prepared for:
Maryland Port Administration
Baltimore, Maryland

Prepared by:
MES Maryland Environmental Service
GBA Gahagan & Bryant Associates, Inc.
MNE Moffat and Nichol Engineers
MGS Maryland Geological Survey

November 2002

EXECUTIVE SUMMARY

In October 2000, the Maryland Port Administration (MPA) and Maryland Department of Transportation (MDOT) completed a report to the Maryland General Assembly Senate Budget and Taxation Committee and House Appropriations Committee regarding the Governor's Strategic Plan for Dredged Material Management (MPA 2000). The report identified James Island as a potential option for habitat restoration using dredged material. The Dorchester County Resource Preservation and Development Corporation had initially recommended James Island as a possible restoration project. In response to this recommendation, conceptual level studies were initiated by the MPA to evaluate James Island as a beneficial use site. James Island currently consists of three privately owned remnants. The island remnants are in Dorchester County on the Eastern Shore of Maryland at the mouth of the Little Choptank River. James Island was estimated at 976 acres in 1847. Recent estimates from 1994 measure the island at 92 acres. Early charts of the area suggest an island footprint of up to several thousand acres.

The Dorchester County Resource Preservation and Development Corporation, a non-profit organization, is interested in stabilizing and protecting the Dorchester County shoreline. This private, non-profit corporation does not have any ownership interest in James Island. The landowners have indicated their willingness to cooperate with the proposed project. Maryland Environmental Service (MES) was contracted by the MPA to perform a conceptual level of study on James Island. The primary study elements include dredging engineering and environmental studies. Limited coastal engineering studies were performed to feed into the dredging engineering study. Maryland Geological Survey (MGS) performed side-scan acoustic profiling and sub-bottom sonar of the site. A total of 5 alignments are under consideration with a 50% wetland to 50% upland split for the restored habitat island.

A site visit to James Island was performed by MES in June 2001 to assess the environmental conditions. It is primarily forested and the shoreline consists of fringe marsh and eroding wooded banks lined with submerged snags. The shoreline elevations are 5-10 ft high on the northwestern shores and gradually decrease in the southern direction. The waters around James Island are relatively shallow and range from 0 to 12 ft in depth. The remnants are currently used for recreation, hunting, and fishing. The island remnants now consist of forested habitat, wet meadow, submerged aquatic vegetation (SAV), marshes, coves, and some beach areas.

Literature search and review by MGS indicate that the geological foundations underlying James Island consist of the Kent, Calvert and Piney Point formations and the Exmore Paleochannel. MGS found that the extent of the sand in the formations is unknown and recommended geotechnical boring collection to identify whether suitable sand is present in the vicinity for dike construction and foundation conditions are adequate for dike construction. MGS also performed side scan sonar and sub-bottom acoustic profiling in 2000 and 2001. Results of these studies will be used to develop the boring plan for further geotechnical studies proposed for James Island.

Moffat & Nichol Engineers, Inc. conducted a preliminary coastal engineering study. Design parameters for wind speed, water level for tides and storm surges, and wave conditions were determined for the prevalent wind and wave directions of north, northeast, south, and northwest. The resulting data was directly incorporated in the site design and dredging engineering analysis developed by Gahagan and Bryant Associates (GBA). The design parameter data indicate that the dike should have an outer slope of 3 horizontal to 1 vertical (3:1) and an inner slope of 5:1. Overtopping computations were used to develop hydrodynamic design parameters for tidal, storm surge, and wave action; the data indicate that the required crest elevations are highest for the northwestern dikes, ranging from 11.8 to 16.4 feet. The maximum size of armor stone for a dike with a 3:1 slope for a 5 year event was 3.1 tons and for a 100-year event was calculated to be 5.6 tons for dike sections exposed to the northwest range.

The site design and dredging engineering element considered five potential configurations for the habitat restoration area. Alignment #1 would have a footprint of 978 acres resulting in the recreation of approximately 489 acres of upland and 489 acres of wetlands. Alignment #2 would have a footprint of 2,126 acres and result in 1,063 acres of upland and 1,063 acres of wetland. Alignment #3 would have a footprint of 1,586 acres and result in 793 acres of upland and 793 acres of wetland. Alignment #4 would have a footprint of 2,200 acres and result in 1,100 acres of upland and 1,100 acres of wetland. Alignment #5 would have a footprint of 2,072 acres and result in 1,036 acres of upland and 1,036 acres of wetland. The wetland cells would require up to an 8-foot armored dike for wave protection. Two upland dike height configurations were examined for each alignment: 10 and 20 ft. The estimated capacities of the alignments range from 24 to 82 million cubic yards (mcy).

The total costs for the project alignments range from approximately $372 million to $1.2 billion. The schedule for initial construction of the restoration area is about 1 – 3 years, depending on the borrow method used. Onsite borrow (alternative borrow method 4) should result in construction times closer to one year, whereas off-site borrow would increase construction time. The total costs per cubic yard of site capacity range from $14.78/cy to $15.91/cy.

The environmental conditions study investigates the current conditions and their potential to be impacted by the project. This conceptual level study includes a review of readily available literature and data. The areas of study include: water and sediment quality, the benthic community, fisheries and aquatic life, submerged aquatic vegetation (SAV), and shallow water habitat, terrestrial habitat, birds and wildlife, historic and recreational resources, and navigation.

Notable current conditions include: significant erosion on the northern remnant on both the west and east sides, degraded benthic habitat, the presence of bald eagles in the area, and natural oyster bars in the vicinity—although no known oyster bars are present within the alignment footprints. Additionally, archeological sites are present on the island but not within the concept areas. Potential effects include short-term water and sediment quality effects, short-term displacement of wildlife, potential impacts to local commercial crabbing, and conversion of shallow water habitat to wetland and upland habitat.

This study and the analyses of its results were intended to be conducted at a conceptual level. Therefore, the following report and the results stated therein should be considered preliminary. Areas of focus for reconnaissance and feasibility studies, if undertaken, are suggested to include: bathymetric, water quality and sediment quality sampling, SAV monitoring, additional biological studies, consultations with resource agencies and historical organizations, and further geological, coastal engineering, dredging engineering, and hydrodynamic investigations. A feasibility study and engineering design would be needed prior to implementation of the proposed project.

This conceptual level study found that a habitat restoration project using dredged material could successfully preserve the remaining island by reducing erosion. The restored habitat could provide additional upland and wetland habitat, and improve water quality in the area and the resulting suspended solids by reducing erosion. Improved water quality could help sustain or improve the oyster and clam fisheries in the area, as well as SAV.

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Appendices

1.0 INTRODUCTION

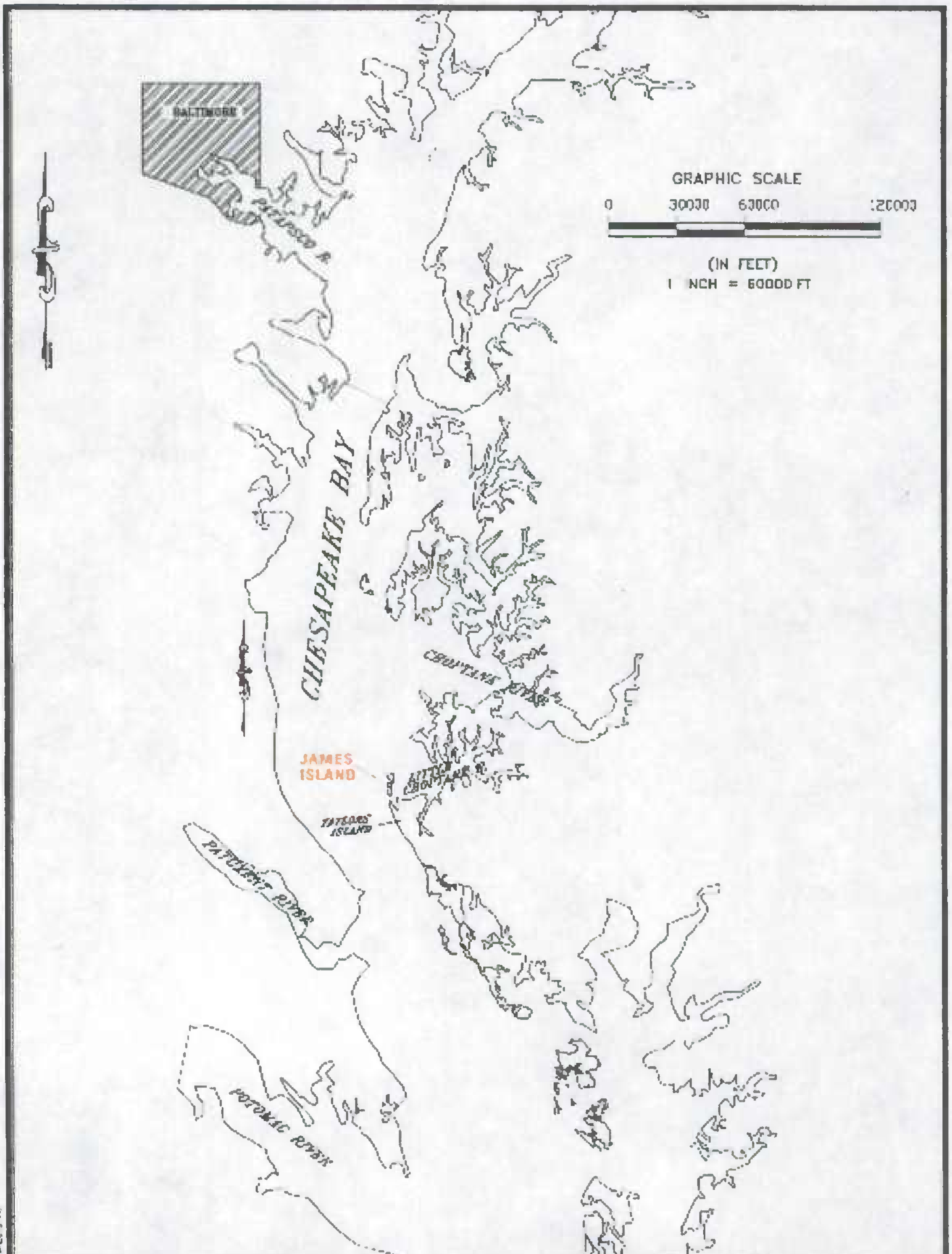
1.1 Site Location

James Island, located in Dorchester County on the Eastern Shore of Maryland (Figure 1.1), is comprised of three privately owned remnant islands located in the mouth of the Little Choptank River. The existing remnant islands were formed as a result of natural processes of shoreline erosion that affect the Chesapeake Bay region. Historically, James Island formed a peninsula off the northern end of Taylors Island; early charts suggest a land mass of up to several thousand acres. Survey data supplied by the Maryland Department of Natural Resources (MDNR) indicates that by 1847 the connection was nearly breached and the island landmass was approximately 976 acres (395 hectares (Ha)) (Figure 1.2). James Island is portrayed on an 1862 Coast and Geodetic Survey nautical chart as being separated from the mainland of Taylors Island by a marsh and a small creek. By 1942, the connection to Taylors Island had been completely breached and consisted of open water. By 1994, the remaining island was breached into two principal remnants (northern and southern remnants) consisting of a total of 92 acres (37 Ha) (Figure 1.2). Between 1847 and 1994, MDNR estimates that 884 acres of James Island were lost to erosion at a rate of six acres per year. James Island suffered significant erosion as a result of Hurricane Floyd in September 1999 and is currently separated into three remnant islands. The three remnants are referred to as the northern, central and southern remnants, for the purposes of this discussion. The northern and central remnants are connected by a sandy strip of land. The southern end of James Island is separated from Taylors Island by approximately 1 mile (1.6 km) of shallow open water.

1.2 Purpose and Needs

The Maryland Dredging Needs/ Placement Options Program (DNPOP) (now the Dredged Material Management Program) for the Port of Baltimore and its participants identified islands in the Chesapeake Bay for conceptual studies as habitat restoration areas using dredged material. Mr. Joe Coyne, President of Dorchester County Resource Preservation and Development Corporation, a non-profit citizens' organization, suggested the possibility of an island restoration project at James Island. The corporation is interested in stabilizing and protecting Dorchester County shorelines. They do not have any ownership interest in the James Island remnants.

In October 2000, the MPA/Maryland Department of Transportation (MDOT) completed a report to the Maryland General Assembly Senate Budget and Taxation Committee and House Appropriations Committee regarding the Governor's Strategic Plan for Dredged Material Management (MPA 2000). In the report MPA identified James Island as a potential option for beneficial use habitat creation using dredged material. The landowner continues to show interest in the use of James Island as a beneficial use and shoreline stabilization project.

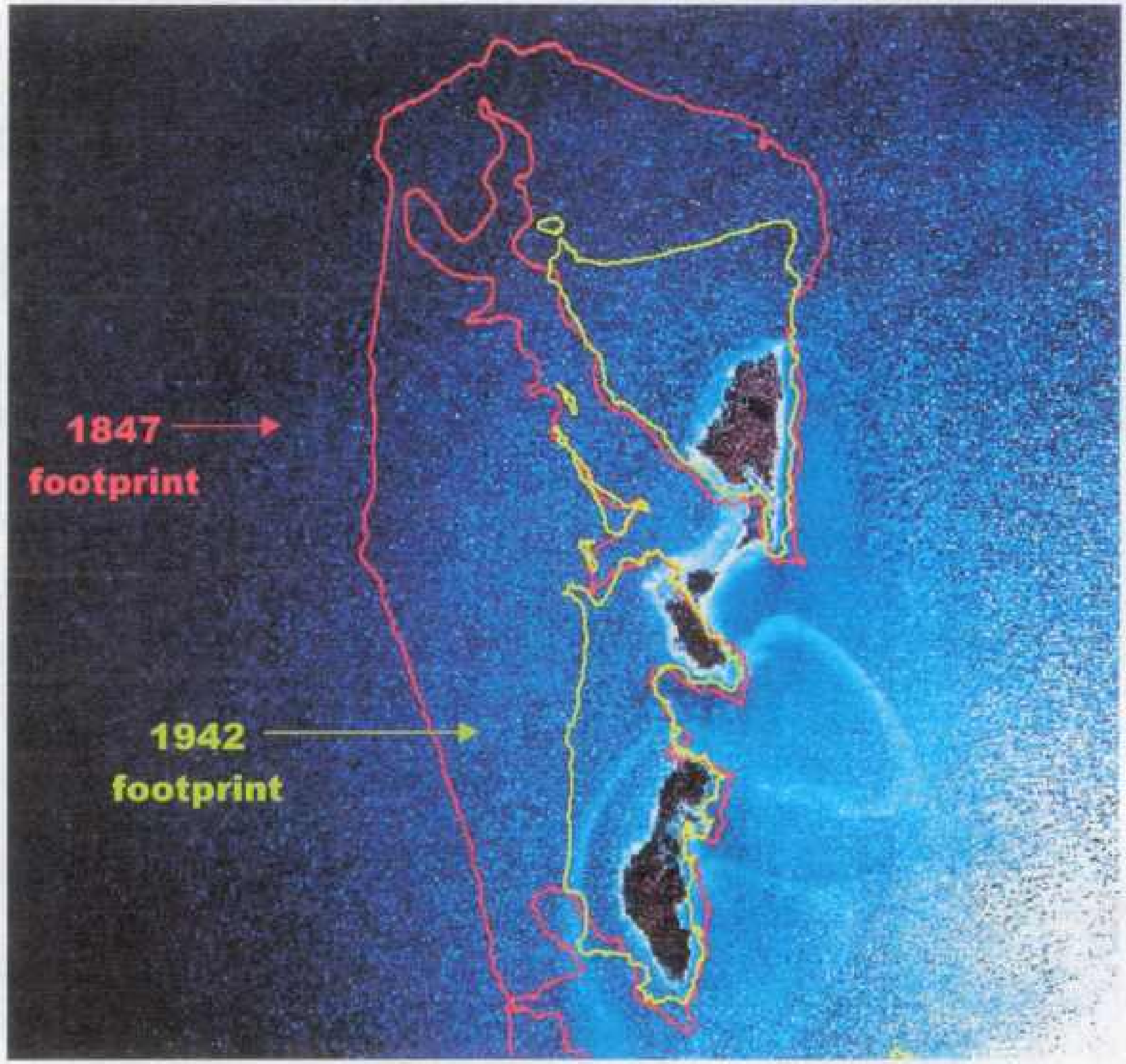


MARYLAND ENVIRONMENTAL SERVICE

FIGURE 1.1
JAMES ISLAND SITE LOCATION MAP

Figure 1.2: Historic Footprints of James Island (1847-1994)

976 acres (1847)
92 acres (1994)
884 acres lost
Rate:
6.0 acres/year



Source:MD DNR Date of Aerial Photo: 1994

Consultation with the owners of James Island and their legal representation by the Maryland Port Administration (MPA) indicate their willingness to cooperate with a proposed project. A variety of conceptual configurations with 50% upland 50% wetland elements were developed covering areas of 978 to 2,200 acres, with a potential capacity ranging from 24 to 82 million cubic yards (mcy) based on conservative planning estimates.

1.3 Scope of Project

MES was contracted by the MPA to carry out a conceptual level study of James Island as a prospective habitat restoration area using material dredged from the approach channels to the Baltimore Harbor. A conceptual study is a first look at the site to see if it has potential merit for future in-depth studies. MES managed and subcontracted specific study elements of the conceptual study to subcontractors.

This report consolidates the findings of several separate investigations, which evaluated the subsurface geological conditions, limited coastal engineering considerations, site design and cost specifications, and the environmental conditions. No geotechnical borings were collected as part of the conceptual study; therefore the site design and cost specifications analyze two separate borrow source options (on and off site) for dike construction. The coastal engineering studies (Appendix B) were intended to provide the rudimentary information needed for site design and cost development. Five alignments were assessed for this placement option. These are outlined in Section 2.3, Section 5.0 and detailed in Appendix C. The environmental conditions study includes an on-site visit by MES staff (Appendix A). During this site visit MES environmental personnel observed all three remnants and were able to explore the central remnant extensively. The findings for each of these technical areas are summarized in the following chapters and detailed in Appendices A-C.

2.0 JAMES ISLAND SITE DESCRIPTION

2.1 Bathymetry & Topography

The James Island remnants are currently less than 100 acres in total size and are decreasing annually due to erosion (Stevenson and Kearney, 1996). The shoreline consists of eroding fringe marsh, eroding sediment bank, and tidal marsh, and eroding wooded upland bank. The eroded banks of the northern remnant have the highest elevation of 5-10 feet (ft). Bank elevations of the James Island remnants decrease gradually in a north to south direction. Prior to its separation from Taylors Island, James Island was once a peninsula enclosing Oyster Cove.

Detailed bathymetric information of the James Island area is limited at this time. Hydrographic data were obtained from National Oceanic and Atmospheric Administration (NOAA) charts shows 1-2 ft of water to the south of James Island (Figure 2.1); however, some boaters with local knowledge use an unmarked channel through the area. The range of water depths in the areas adjacent to the remnant islands are 1-8 ft to the east, 4-12 ft to the north, and 1- 6 ft to the west. Water depths are relatively shallow around the island within the proposed project area. The water depth in which the dikes would be constructed vary from ~3 to 12 ft MLLW. Further bathymetric data would be needed to support implementation of a placement option at this location.

2.2 General Habitat Descriptions

The three privately owned remnant islands are used recreationally for hunting and fishing. Several duck blinds can be found along the shoreline (central and southern remnant). No housing structures were observed during the site visit by MES (Appendix A), although evidence indicates that dwellings did exist on the island in the past.

The interior habitat on James Island primarily consists of upland forested habitat containing pines, spruces and some deciduous tree species. A wet meadow is located on the northern remnant and contains emergent plants in standing water that appears to be freshwater. The meadow appears to be manmade and enclosed by 1-2 ft berms on three sides (Photo 1). The shorelines consist of fringe marsh and eroded wooded banks of 5-10 ft lined with submerged snags. General elevations of the shoreline

Photo 1. The wet meadow located on the northern remnant.

gradually decrease from the northern to the southern remnants. Most of the steep wooded banks are on the northern remnant; while much of southern remnant shoreline consists of fringe marsh. The northern remnant is connected to the central remnant by a sandy spit of land; two brackish tidal ponds were located on the sandy spit (Photo 2). The central remnant is separated from the southern remnant by a tidal gut.

Photo 2. The northern (right) and central (left) remnants linked by the sandy spit.

Submerged aquatic vegetation (SAV) was present in a cove on the eastern side of the north and central remnant. A more detailed description of SAV is included in Section 6.1.5. There are three state-recognized natural oyster bars (NOBs) near James Island. They are located outside the footprints of the proposed alignments. The NOBs are depicted in Figures 2.1-2.5 and discussed in further detail in sections 6.1.10.

2.3 Proposed Site Alignments

Five potential alignments were considered for this study (Figures 2.1-2.5) and are discussed in the Gahagan and Bryant Associates (GBA) report attached in Appendix C. Alignment #1 would have a footprint of 978 acres resulting in the restoration of approximately 489 acres of upland and 489 acres of wetlands. Alignment #2 would have a footprint of 2,126 acres and result in 1,063 acres of upland and 1,063 acres of wetland. Alignment #3 would have a footprint of 1,586 acres and result in 793 acres of upland and 793 acres of wetland. Alignment #4 would have a footprint of 2,200 acres and result in 1,100 acres of upland and 1,100 acres of wetland. Alignment #5 would have a footprint of 2,072 acres and result in 1,036 acres of upland and 1,036 acres of wetland. It was assumed that the wetland cells would be on the eastern side of the foot print and would require up to an 8-foot dike for wave protection as with Poplar Island Environmental Restoration Project. Two different upland dike heights were examined for each alignment: 10 and 20 ft. The capacities and estimated costs for each alignment are discussed further in Section 5.0.

3.0 SUBSURFACE GEOLOGICAL INVESTIGATIONS

Geological studies are an important factor in this conceptual study. Island habitat restoration projects that that are enclosed by dike systems require a suitable source of sand for dike construction of the containment dikes for possible use in establishing suitable foundation conditions. The Maryland Geological Survey (MGS), Coastal and Estuarine Geology Program undertook a preliminary assessment of the local geology based on data that was readily available to MGS. Data available included acoustic sub-bottom profiling information, county water resources reports, and geological maps. In addition, side-scan sonar and sub-bottom acoustic profiling was conducted by MGS in 2000 and 2001. No borings were collected during this conceptual study.

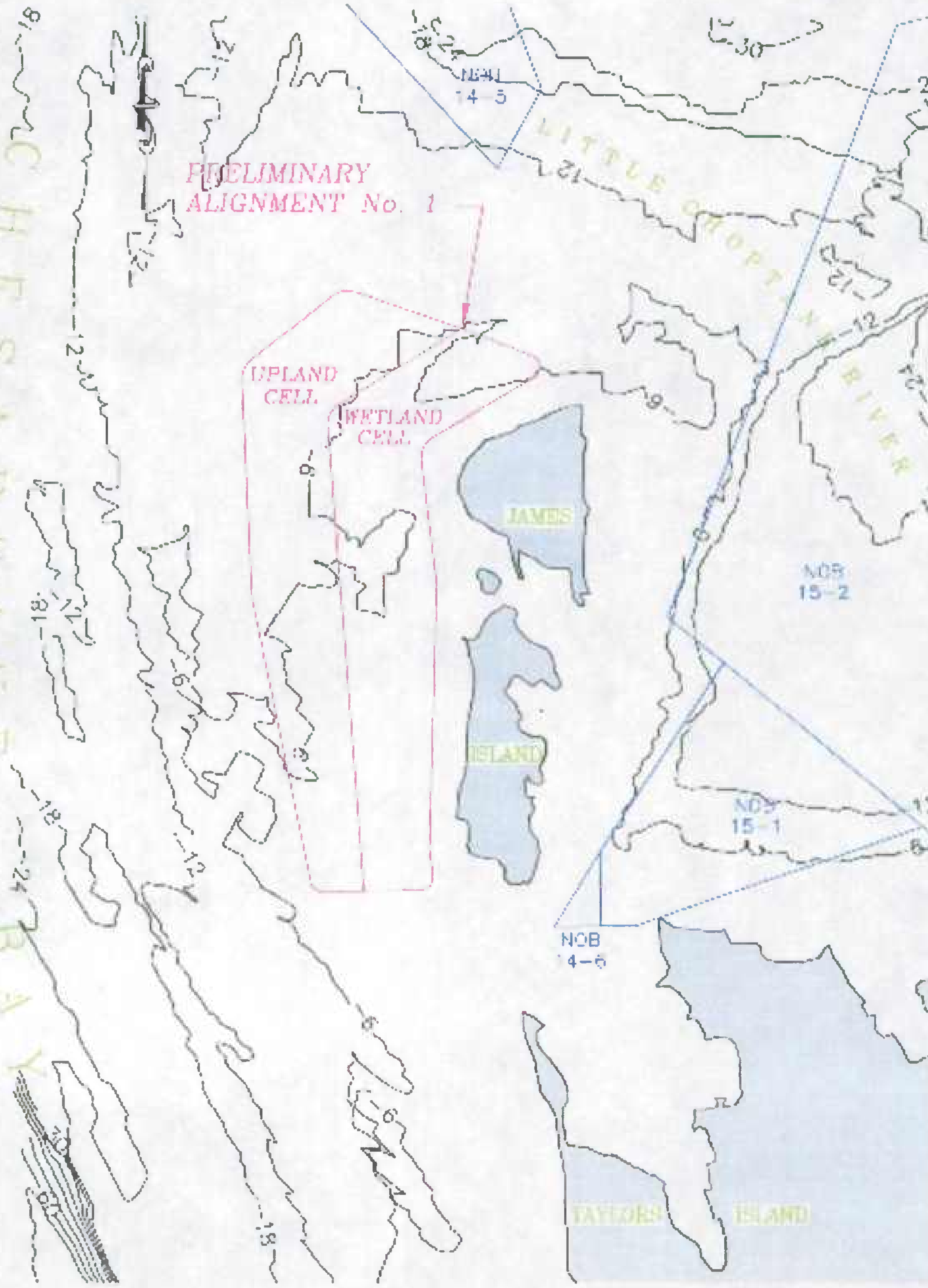


FIGURE 2.1: JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 1

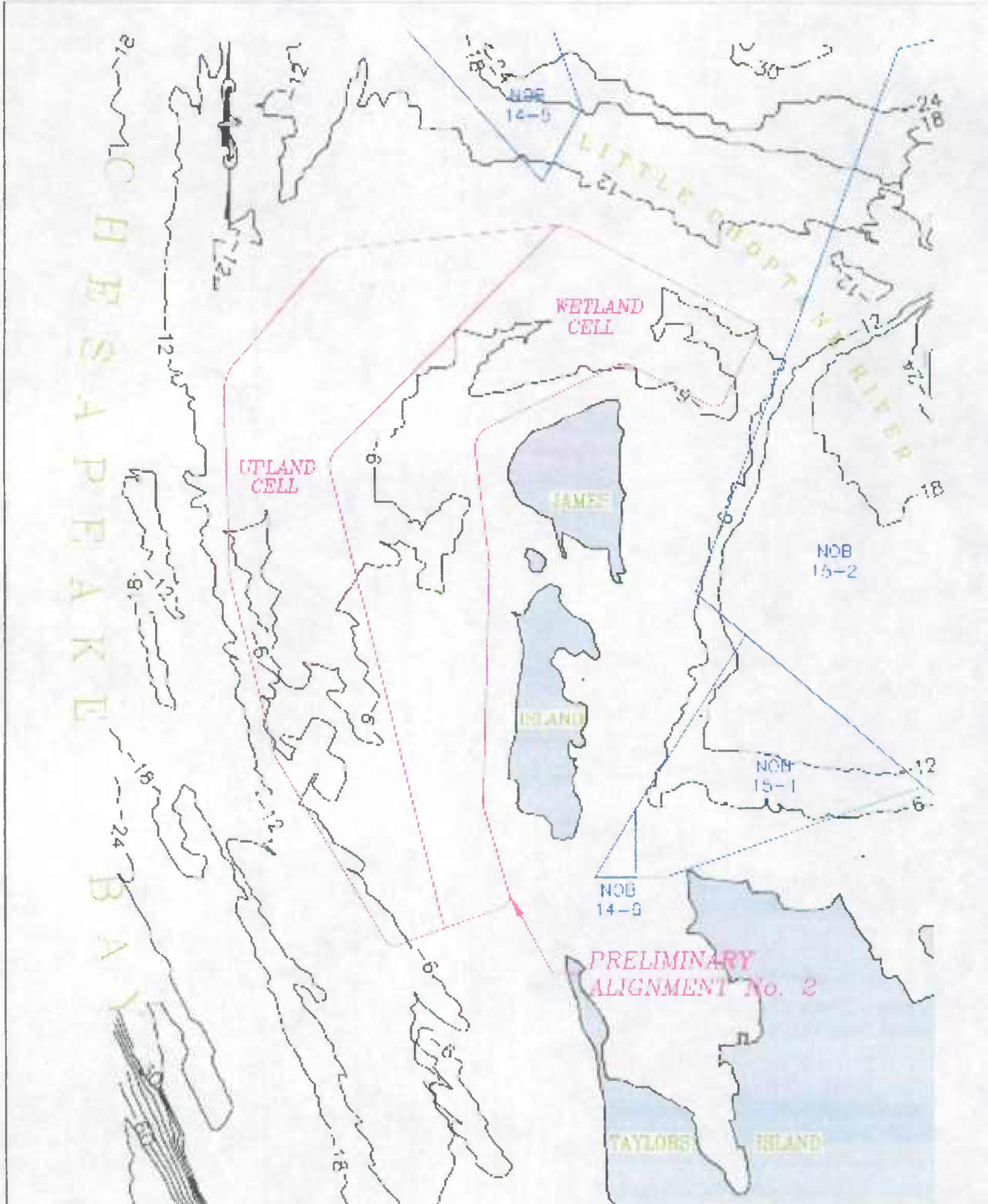


FIGURE 2.2. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 2

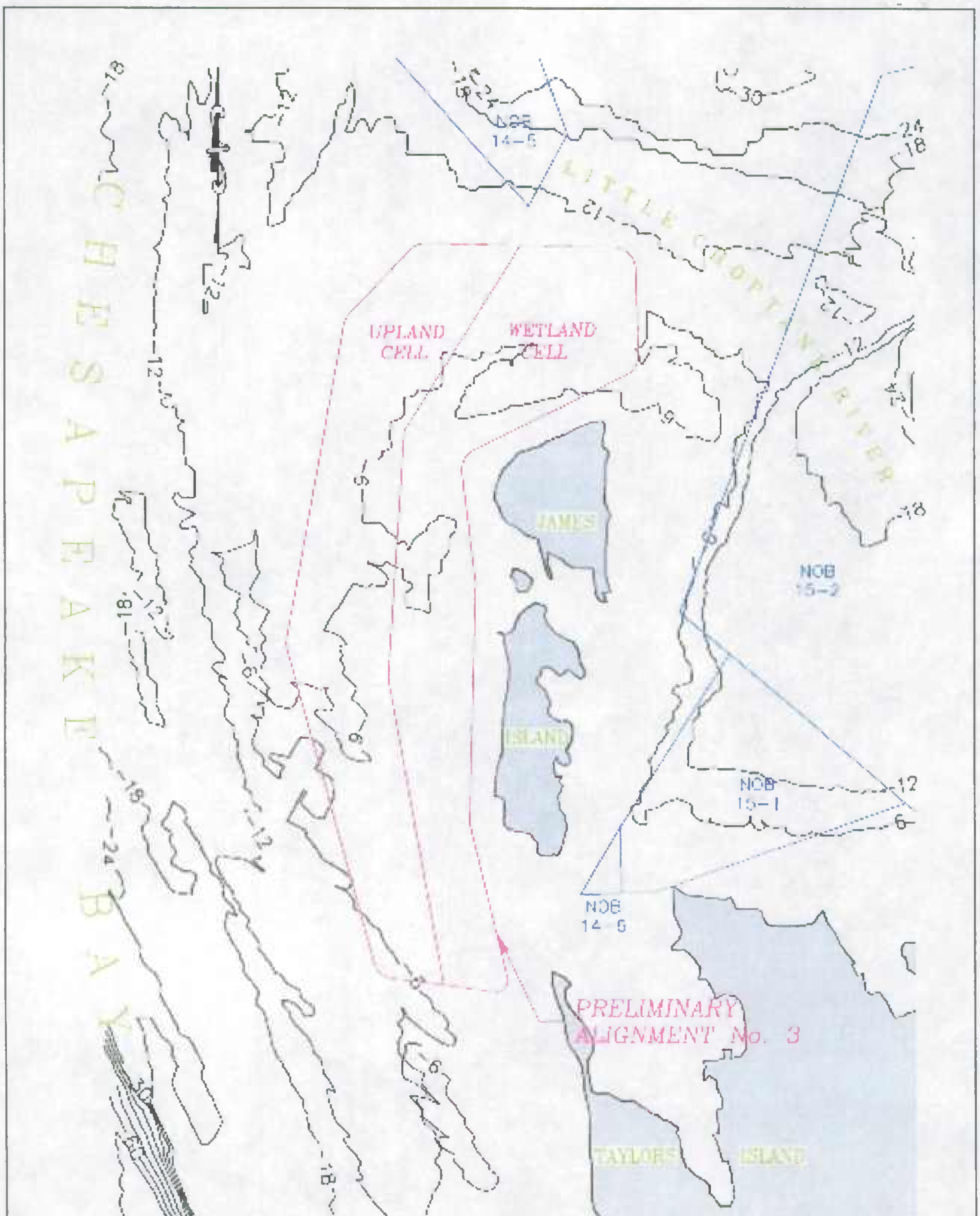


FIGURE 2-3. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 3

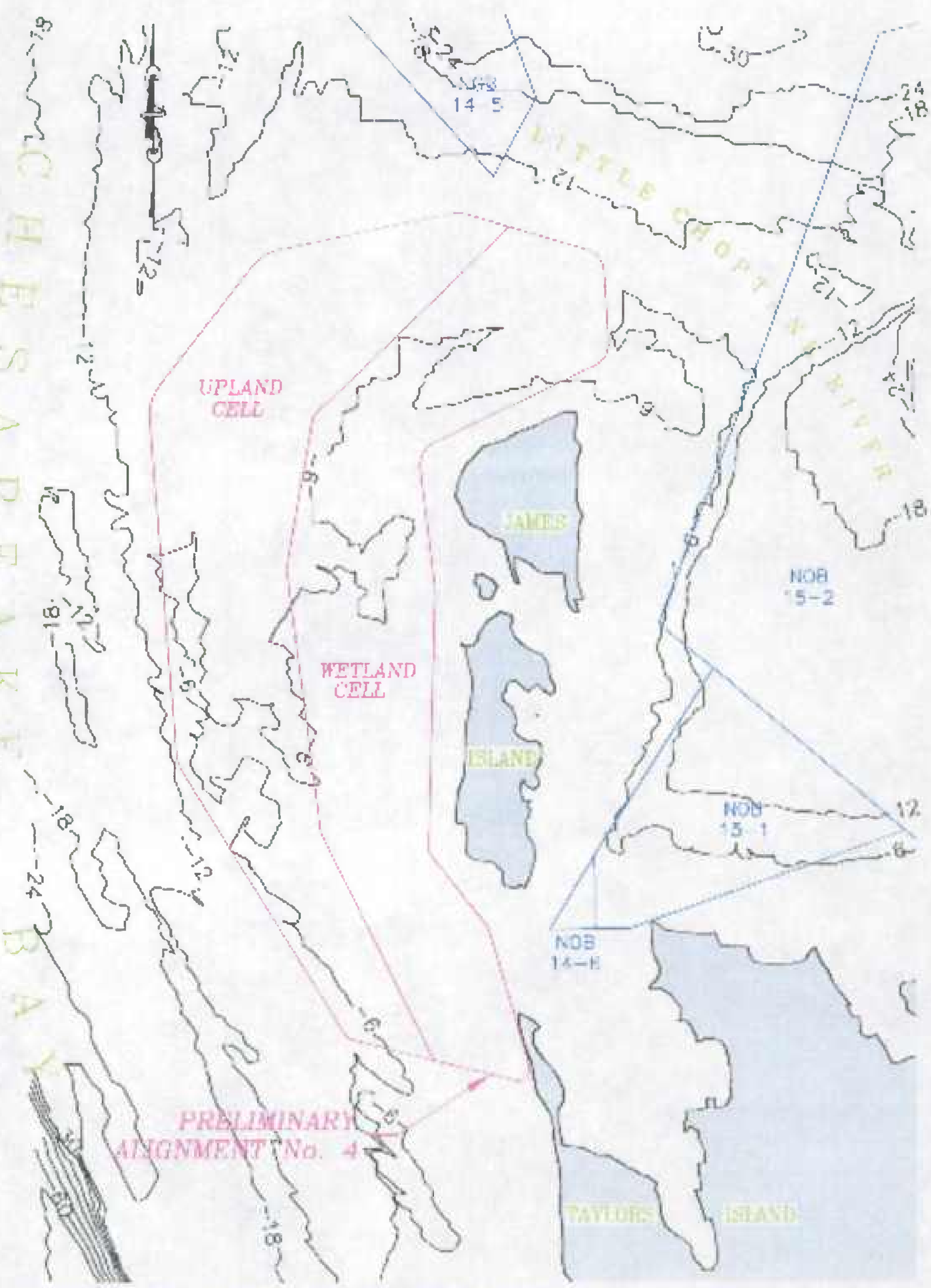


FIGURE 2.4. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 4

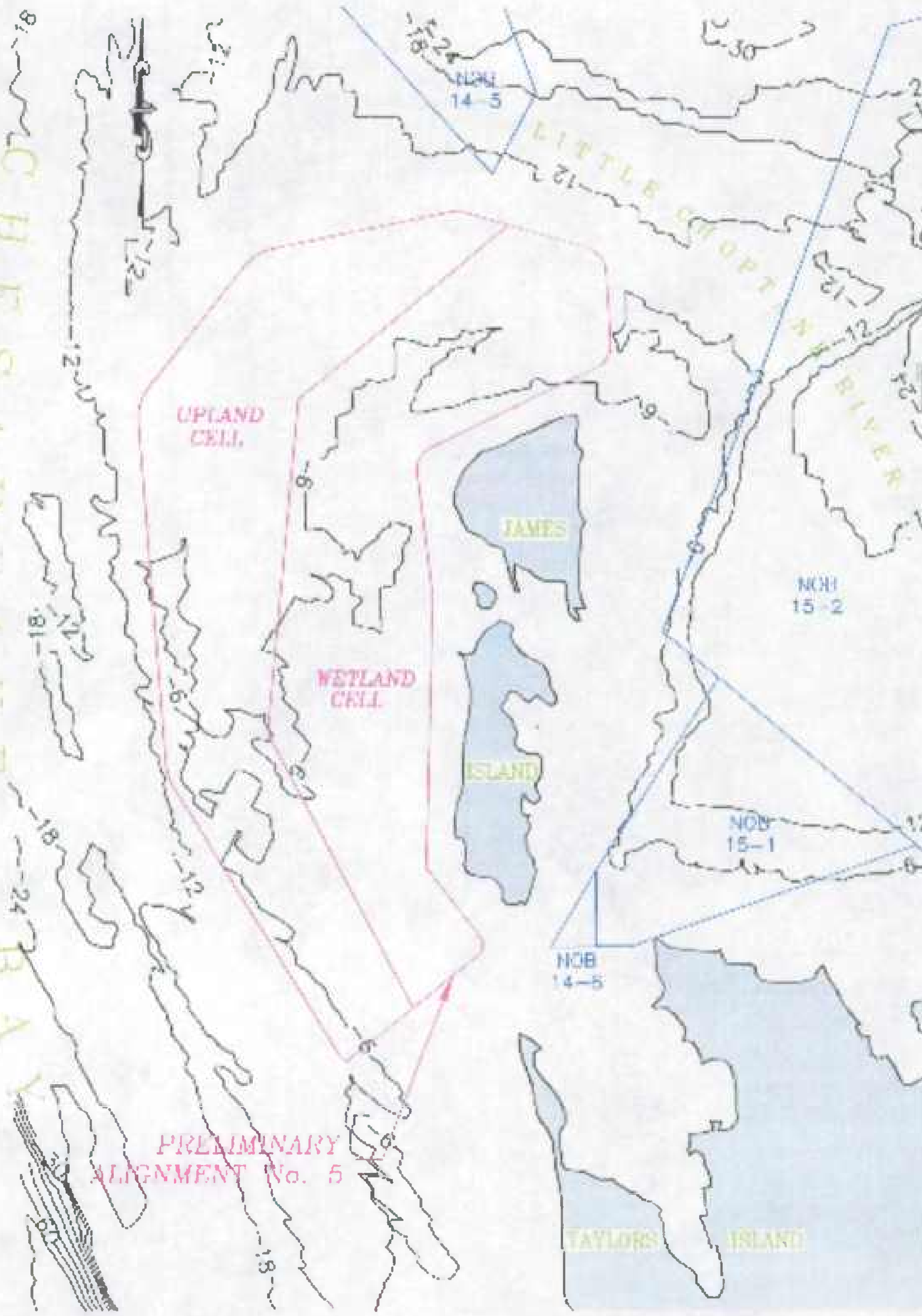


FIGURE 2.5. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 5

This assessment assists in summarizing the regional geology and provides a basis for determining the need for more detailed subsurface investigations should the project move forward.

3.1 Summary of Background Efforts

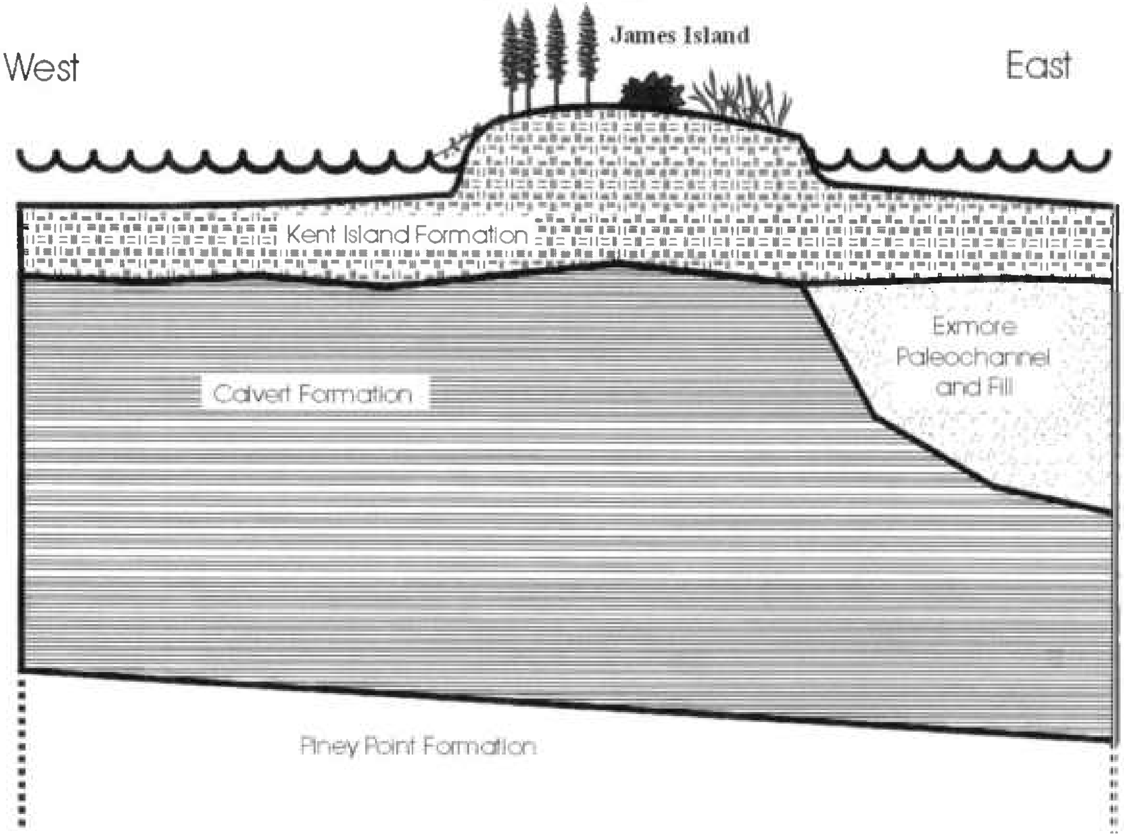
In the spring of 2000, MGS performed a preliminary analysis of subsurface conditions in the James Island vicinity. This literature search and review consisted of a desktop interpretation of probable geological conditions. A short report was produced in March 2000, entitled "Preliminary Investigations of the Subsurface Geology in the Vicinity of James Island, Dorchester County" (Halka, 2000). This document is summarized in Section 3.2 and attached in Appendix B.

MGS reported in the March 2000 report that the reflectors observed in the acoustic sub-bottom profiles, which include the sediments below the platform surrounding James Island, consist of three formations and a filled paleochannel (Figure 3.1). Over the entire area the upper 7-10 ft (2-3 m) of sediment represents the Kent Island Formation, which generally overlies the Calvert Formation. The Calvert Formation extends to a depth of approximately 207 ft (63 m) and overlies the Piney Point Formation. To the east of James Island a channel has been cut into the Calvert Formation by a paleo-Susquehanna River and was subsequently filled with sediments.

According to the MGS report, the Kent Island Formation, comprising the upper 7-10 ft (2-3 m) of sediment, is likely to consist predominantly of fine grained silts and clays that were deposited in the estuarine environment of a proto-Chesapeake Bay. While there may be some areas of sandier sediments located within this formation they are likely to be limited. It is reported to be unlikely that the Kent Island Formation would provide a suitable source of sand for dike construction. Furthermore, it would probably need to be removed to reach any underlying sediment. Similarly, MGS believes the paleochannel located to the east of the Island is likely to be filled with fine grained sediments that were also deposited in an estuarine environment. In this area the fine-grained sediments are likely to extend to depths in excess of 49 ft (15 m) below the present water surface.

MGS is less certain of the textural characteristics of sediments that locally compose the underlying Calvert Formation. Owens and Denny (1986) are quoted in the MGS report stating that the Kent Island Formation overlies black clay under Dorchester County, but this may or may not apply to the James Island area. It is theorized that fine to medium grained sand underlies the Kent Island Formation in the vicinity of Slaughter Creek, and there appears to be a lacking gravel layer (Halka, 2000). It is not certain that sediments with these characteristics would extend from Slaughter Creek to the vicinity of James Island. The MGS report cites studies noting that beds of the Calvert and Choptank Formations are laterally extensive and that the uppermost interval of the Calvert Formation has variable amounts of sand at least in the Calvert Cliffs area. It is uncertain that these sediment characteristics can be extended across the Bay to James Island vicinity. The MGS report provides boring location recommendations; given the laterally extensive nature of the sediments in this formation a sufficient number of borings in the

Figure 3.1: Conceptual Drawing of Geological Formation Cross Sections of James Island



vicinity of James Island may serve to identify whether or not suitable sand is present in the upper portions of the Calvert Formation. The majority of the borings are recommended to be located to the west of the island where the Calvert Formation is likely to be encountered at shallower depths. To the east of the island the Calvert was eroded to greater depths due to the downcutting of the Exmore paleochannel. Some borings are recommended in this area to better define the location and depths of this paleochannel although it is likely to be filled with muddy sediments rather than sand.

The accompanying Figure 3.1 characterizes this interpretation of the local geology. The figure shows a cross section of the area from due south of James Island looking to the north. The main stem of the Chesapeake Bay is located to the left of the figure. Note that the figure is conceptual only. A scale is not shown because no actual data exists for subsurface sediments in the area immediately underlying the island and surrounding vicinity. The base of the Kent Island Formation is probably located 16-20 ft (5-6 m) below the present water surface, and the interface between the Calvert and Piney Point Formations at a depth of over 197 ft (60 m). The location, slope and depth of the Exmore Paleochannel and fill are less certain in the area immediately to the east of James Island.

3.2 Site Specific Data Collections - 2000 and 2001 Field Studies

MGS collected acoustic sub-bottom profile data around James Island on May 26, 2000. Data were collected for the general concept area, beginning from a line approximately 2100 yd (1900 m) west of James Island, shoreward to the shallowest practical water depth for this technique of approximately 6 ft (1-2 m). The near-surface geology in the vicinity of James Island is complex; the data collected from this effort will be used by the design engineers and drilling contractors to develop a boring plan.

MGS also collected side-scan sonar data around the James Island site on August 7, 2001. These data have not been interpreted by MGS, but could be useful should the study move forward for establishing the bottom conditions at the sediment interface, the near bottom hydrodynamic conditions or locations of living resource habitats, such as oyster bars and sand waves.

3.3 Summary

From the background information available, the Kent Island Formation is likely to consist predominantly of fine-grained silts and clays. While some sandier sediment may be located within this formation, they are likely to be limited. It is unlikely that the Kent Island Formation would provide a suitable source of sand for dike construction. Furthermore, this overlying sediment would probably need to be removed to reach any underlying dike quality sediment. Similarly, the paleochannel is likely to be filled with fine-grained sediments which are likely to extend to depths in excess of 50 ft (15 m) below the present water surface.

The composition of the Calvert Formation is less certain, due to the lack of supporting data, and could only be extrapolated from other areas of the Bay to James Island vicinity.

Due to the laterally extensive nature of the sediments in the Calvert Formation, MGS suggests that borings in the vicinity of James could serve to identify whether or not suitable sand is present in the upper portions of the Calvert Formation. A majority of the borings should be located to the west of James Island, which is the area of the proposed project. Additionally, borings to the east of James Island would serve to identify the location and depth of the paleochannel, which is likely to be filled with muddy sediments

MGS is available to interpret the results from the acoustic sub-bottom data and assist in selecting the location of borings that may be collected around the island for assessment of foundation conditions and potential sand borrow areas should the James Island study progress to pre-feasibility level.

4.0 COASTAL ENGINEERING INVESTIGATION

Moffatt and Nichol Engineers (M&N) conducted a coastal engineering study to ascertain physical conditions that would affect a restoration project and to identify coastal engineering planning for design factors. These results were submitted to GBA and incorporated into the Dredged Material Placement Site Construction Report (Appendix C). The coastal engineering investigation used historic data on wind conditions, water levels, wave conditions, and dike design parameters for James Island to determine dike construction parameters.

4.1 Wind Conditions

Annual extreme wind speed data from the National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC) for Baltimore-Washington International (BWI) Airport, for the period 1951 through 1982, were used in estimating wind conditions for this study (National Ocean Service (NOS) 1982 and NCDC 1994). The wind data were used to develop wind speed-return period relationships based on a Type I (Gumbel) distribution for eight directions: North (N), Northeast (NE), East (E), Southeast (SE), South (S), Southwest (SW), West (W) and Northwest (NW). The prevalent wind directions that would impact James Island originate from the N, NE, S and NW directions; therefore, these data for these wind directions are presented in Table 4.1. The specific return periods, the average time between wind events which equal or exceed a given value, examined were 5, 10, 15, 20, 25, 30, 35, 40, 50 and 100 years. The following table shows the design wind speeds for these return periods and the prevalent wind direction. The design wind speeds have been used to estimate design wave conditions for the proposed concept.

Table 4.1 Design Wind Speeds per Direction and Return Period (mph)

Return Period	N	NE	S	NW
	Direction			
5	40	37	36	54
10	48	44	43	59
15	52	48	47	62
20	56	52	51	65
25	59	55	54	67
30	62	57	56	68
35	64	60	58	70
40	66	62	60	71
50	69	66	63	73
100	81	76	74	81

4.2 Water Levels

Tidal datum characteristics for locations near the project site reported from National Ocean Service (NOS) are presented in table 4.2.

Table 4.2 Astronomical Tidal Datum Characteristics for Selected Chesapeake Bay Locations (ft, MLLW)

Tidal Datum	Taylors Island Slaughter Creek	Sharps Island Light	Cove Point
Mean Higher High Water (MHHW)	1.6	1.7	1.7
Mean High Water (MHW)	1.4	1.5	1.5
Mean Tide Level (MTL)	0.9	0.9	0.9
National Geodetic Vertical Datum (NGVD)	0.3	0.3	0.2
Mean Low Water (MLW)	0.2	0.2	0.2
Mean Lower Low Water (MLLW)	0.0	0.0	0.0

Design water levels for the study site areas are dominated by storm effects (i.e. storm surge and wave setup) in combination with astronomical tide. A comprehensive evaluation of storm-induced water levels for several Chesapeake Bay locations has been conducted by the Virginia Institute of Marine Science (VIMS) (1978) as part of the Federal Flood Insurance Program. Results of this study for the James Island vicinity are summarized in Table 4.3, showing water level versus frequency curves.

4.3 Storm Surge Water Levels (ft, MLLW)

Return Period	Water Level
5	3.8
10	3.9
15	4.1
20	4.2
25	4.4
30	4.5
35	4.7
40	4.8
50	5.1
100	5.7

4.3 Wave Conditions

James Island is exposed to wind-generated waves approaching from all directions; however, the largest waves that would impact the island originate from the N, NE, S and NW directions. A radially averaged fetch distance was computed for these four directions. The fetch distances and mean water depths along the fetch directions are shown in Table 4.4.

Table 4.4 Radial Fetch Distances, Mean Value and Mean Water Depth for Radially-Averaged Fetch

Direction	Mean Fetch Distance (Miles)	Mean Water Depth (ft, MLLW)
North	8	13
Northeast	4	20
South	60	50
Northwest	30	50

Waves were hindcast for the four directions using methods published in the Shore Protection Manual (1984). A sea state is normally composed of a spectrum of waves with varying heights and periods. In order to summarize the spectral characteristics of a sea state it is customary to represent that wave spectrum in terms of a distribution of wave energy over a range of wave periods. Having made this distribution, known as a wave spectrum, it is convenient to represent that wave spectrum by a single representative wave height and period. The wave conditions reported in Tables 4.5 and 4.6 are the offshore significant wave height, H_s, and the peak spectral wave period, T_p,, respectively. The significant wave height, H_s, is defined as the average of the highest one-third of the waves in the spectrum. The peak spectral period, T_p, is the wave period, which corresponds to the maximum wave energy level in the wave spectrum. Tables 4.5 and 4.6 present H_s and T_p for the four directions from which the highest waves and longest periods approach the site.

Table 4.5 Wave Heights per Direction and Return Period (ft)

Return Period	Direction N	NE	S	NW
5	3.0	2.2	6.9	8.1
10	3.6	2.7	8.1	8.8
15	3.9	2.9	8.7	9.2
20	4.2	3.2	9.4	9.7
25	4.4	3.4	9.8	9.9
30	4.6	3.5	10.1	10.1
35	4.8	3.7	10.4	10.3
40	5.0	3.8	10.7	10.5
50	5.2	4.1	11.2	10.8
100	6.1	4.7	12.7	11.8

Table 4.6 Wave Periods per Direction and Return Period (seconds)

Return Period	Direction N	NE	S	NW
5	3.4	2.8	5.7	5.8
10	3.7	3.0	6.2	6.0
15	3.8	3.1	6.4	6.1
20	3.9	3.2	6.6	6.2
25	4.0	3.2	6.7	6.3
30	4.1	3.3	6.8	6.3
35	4.1	3.3	6.9	6.4
40	4.2	3.4	7.0	6.4
50	4.3	3.5	7.2	6.5
100	4.5	3.7	7.6	6.8

4.4 Dike Design Parameters

The dike geometry used for this preliminary study is comprised of toe protection, a rubble mound revetment (i.e. the side slope), a horizontal crest with a crushed stone roadway and a core constructed of sand. One of the more important variables of the dike design is the side slope, which together with the crest height, is generally dictated by soil conditions and dike construction methodologies. Based on the analyses performed for prior projects, and the geotechnical analysis performed for this project, the dike design has been determined to have an outer slope of 3 horizontal to 1 vertical (3:1) and an inner side slope of 5 horizontal to 1 vertical (5:1).

The dikes must be designed for a given level of hydrodynamic design conditions including winds, waves, water levels, and currents. Overtopping computations were used to develop required crest elevations for construction of a dike with no armor stone on the crest or back slope. The results are summarized in the following table and are based on structures constructed in water depths of 12 ft exposed to N and NW waves, water depths of 6 ft exposed to the south and water depths of 2 ft exposed to the NE.

Table 4.7 Crest Elevation per Direction and Return Period (ft)

Return Period	Direction N	NE	S	NW
5	6.4	4.5	8.8	11.8
10	7.4	4.9	9.1	12.3
15	8.1	5.2	9.4	12.8
20	8.9	5.4	9.6	13.2
25	9.5	5.7	9.9	13.5
30	10.2	5.9	10.2	13.8
35	10.7	6.2	10.5	14.1
40	11.3	6.4	10.8	14.4
50	12.4	6.8	11.3	15.0
100	15.2	7.8	12.4	16.4

According to Table 4.7, required crest elevations for James Island are highest for dikes exposed to waves from the northwest, and range from about 11.8 ft MLLW for a 5-year storm to about 16.4 ft MLLW for a 100-year event. The lowest required crest elevations for James Island are for a dike exposed to waves from the northeast, and range from about 4.5 ft to 7.8 ft for a 5-year to 100-year storm, respectively.

The Table 4.8 presents the stone sizes (computed using Van der Meer's method for breaking and non-breaking waves) for a 3:1 side slope. For James Island, required stone sizes for dike sections exposed to the northwest range from 3.1 tons for a 5-year return period to 5.6 tons for a 100-year return period, for a structure in 12 ft of water. The armor stone requirements assume that the armor layer for the dike revetments will consist of two layers of placed rock.

Table 4.8	Armor Stone Size per Direction and Return Period (tons)			
Return Period	Direction			
	N	NE	S	NW
5	0.3	0.1	1.3	3.1
10	0.5	0.1	1.5	3.5
15	0.6	0.1	1.7	3.7
20	0.8	0.1	1.9	3.9
25	0.9	0.1	2.0	4.1
30	1.0	0.2	2.1	4.2
35	1.1	0.2	2.3	4.4
40	1.2	0.2	2.4	4.6
50	1.4	0.2	2.6	4.8
100	2.3	0.3	3.3	5.6

5.0 DREDGING ENGINEERING AND COST ANALYSIS

GBA performed a dredging engineering conceptual level assessment for the pre-feasibility of constructing an island habitat restoration project using suitable dredged material at James Island.

GBA evaluated the suitability of this site for construction of two dike height scenarios for five island habitat restoration area alignments. Each dike alignment is characterized by a 10 ft or 20 ft upland dike height and an 8 ft high wetland dike. Each alignment has a 50% upland and 50% wetland component. Estimated costs of borrow source options were investigated: on-site and off-site. This following summarizes the findings of this assessment.

5.1 Site & Design Characteristics

GBA, M&N, and MES coordinated the design of the dike alignment options and two upland dike height options for each dike alignment for quantity tradeoffs and cost estimates. Existing oyster bars are located in the vicinity of James Island, but not within any of the five proposed dike alignments. Twenty alignments and dike height scenarios and corresponding centerline areas are summarized in Table 5.1, previously shown in Figures 2.1-2.5. Site characteristics for all dike alignments and dike heights including quantities for rock armor and hydraulic fill material are provided in Appendix C Tables A1-A5. Some alignments are close enough to Taylor Island to potentially support connection by a bridge or causeway. A further study would be needed to evaluate the bridge or causeway construction issues, including costs hydrodynamic effects, water quality, and effects to navigation.

Table 5.1: Dike Alignments with wetland and upland areas for each dike heights

	Alignment #1	Alignment #2	Alignment #3	Alignment #4	Alignment #5
Acres	978	2,126	1,586	2,200	2,072
Wetland Capacity	5.5 mcy	15.4 mcy	10.6 mcy	11.2 mcy	10.5 mcy
Upland Capacity (10 foot dike)	18.1 mcy	39.4 mcy	27.7 mcy	43.1 mcy	40.6 mcy
Upland Capacity (20 foot dike)	30.3 mcy	65.8 mcy	47.4mcy	70.4 mcy	66.3 mcy
Total Capacity (10 foot diked upland)	23.6 mcy	54.8 mcy	38.3 mcy	54.3 mcy	51.2 mcy
Total Capacity (20 foot diked upland)	35.8 mcy	81.2 mcy	58.0 mcy	81.6 mcy	76.9 mcy

James Island is periodically exposed to heavy wave action on the north, south and west sides of the island. Therefore, typical dike sections similar to those built at Poplar Island may require heavy armor for the northern, southern and western dike exposures. The east dike would receive protection from the James Island remnants, so it could be smaller with less rock armor and no toe dike (Appendix C Figures 7 and 8). The relatively shallow shelf to the south, west, and north is more extensive than at Poplar Island, and would seem to dissipate wave energy to some extent. Therefore, the analogy to Poplar Island is a reasonable but not an exact approximation.

Bathymetric and geotechnical information for the James Island area is limited for the conceptual level of study. Nautical charts show less than 2 ft of water to the south of James Island adjacent to Taylors Island. However, commercial fishing and pleasure boats use an unmarked channel between James and Taylors Island that has been created by natural processes.

Additional bathymetric and geotechnical data would be required for the pre-feasibility and design phases of this project, if undertaken.

5.2 Alternate Borrow Methods

The estimated neat sand fill quantities for construction of James Island range from 1.7 to 4.2 million (Tables A1 to A5 in Appendix C). In addition to fill quantities for the perimeter dike, this estimate includes sand for interior dikes to divide the island into placement cells, and sand to backfill potentially unsuitable foundation areas along the perimeter dike.

Four different methods for providing sand borrow have been considered to meet the estimated quantities: (1) mine sand from a land based quarry and transport it by truck; (2) mine sand from a quarry and transport it by barge; (3) dredge and transport off-site sand by hopper dredge to an underwater placement site and place sand in dikes with a hydraulic dredge; and (4) hydraulic dredge directly from on-site borrow area. Alternate borrow methods 3 and 4 were assessed by the study team as the most feasible methods investigated and were therefore used for estimating costs.

Alternative borrow method 3 assumes that suitable fill material is not available within 2 or 3 miles and must be transported by hopper dredge from about 30 miles away from Craighill Channel (off-site). After transport, the material would be bottom released in an underwater stockpile located on site and pumped into section by a small hydraulic dredge. Alternatively, if the water depths were too shallow for bottom placement, material would be pumped hydraulically by a hydraulic unloader to either a stockpile or directly to the construction area.

Alternate borrow method 4 assumes suitable on-site sand fill is available and pumped into a stockpile and then hauled, shaped into section and armored. This method of dike building was the most effective method that was used to construct the Poplar Island Environmental Restoration Project.

5.3 Cost Analysis

GBA summarized the estimated initial construction costs in Appendix C, Table 6 and the total site use costs in Appendix C, Table 7.

The initial construction costs consist of preliminary construction plus conceptual, pre-feasibility, and feasibility study costs. The preliminary construction costs are broken down by line item, borrow source, and dike height (20 alternatives). The initial construction costs range for all alignments, both upland cell elevations options, and both borrow methods range from is $49.9 to $90.4 million. The unit costs for initial construction of the dike system range from $1.00/cy to $2.26/cy.

The total site use cost analysis for each dike alignment and dike height is comprised of a initial construction cost; site development cost (dredge material management, site maintenance and site monitoring and reporting); habitat development cost (plans and design, monitoring, implementation, and project operation & maintenance); and dredging, transport and placement cost (mobilization & demobilization, dredging, transport, and placement). The total cost range for each alignment, upland dike height and borrow source alternative are $371.5 million to $1.22 billion. The total units cost for all alignments, dike heights (10 or 20 ft) and borrow source (onsite or offsite) range from $14.78/cy to $15.91/cy (Table 7 Appendix C).

5.4 Summary

The range of total costs for construction is from about $372 million to $1.22 billion. The schedule for construction is about 1 – 3 years, depending on the extent of the dike system and the borrow method used. The easiest, quickest, and least costly borrow source, if available, would most likely be onsite borrow (borrow method 4). This option would result in construction times of approximately one year to eighteen months, which would be considerably less than any of the other borrow alternatives.

When all factors associated with moving maintenance material from the Baltimore Harbor approach channels to the James Island are considered, the total costs per cubic yard of site capacity range fom $14.78/cy to $15.91/cy. Alignment 1 has the least placement potential, the lowest total site use cost, and the highest unit cost. Alignments 2, 4, and 5 have the greater placement potential, highest total site use cost, and the lowest unit cost.

Certain factors may change the costs estimated in this report. A 15% contingency cost is included to offset unforeseen developments. For example, dredging industry conditions and fuel prices drive the cost of dredging, transport and placement of maintenance material. As for initial construction costs, construction industry conditions and the limited geotechnical information available at this time may be the most likely cause of additional costs. For example, a modest reduction in cost per cubic yard for onsite borrow material may potentially be realized if there were to be increased capacity from any borrow pit within the island alignment.

It is important to note that the analysis in this study was conducted at a conceptual level and therefore, the results should be considered preliminary. A higher level pre-feasibility study and engineering design would be needed to implement the proposed beneficial use of dredged material project.

6.0 ENVIRONMENTAL CONDITIONS

James Island is located in the southern portion of the mouth of the Little Choptank River on the Eastern Shore of Maryland, and is surrounded by shallow water habitat. Waters of the Little Choptank River are to the east of James Island and the waters of the Chesapeake Bay are to the west.

MES conducted a conceptual level environmental study relating to the construction of a habitat restoration area using dredged material at James Island. This conceptual level study included reviews of readily available literature and on-line data to assess impacts of the habitat restoration project to water and sediment quality, the benthic community, fisheries and aquatic life, submerged aquatic vegetation (SAV) and shallow water habitat, terrestrial habitat, birds and wildlife, historic and recreational resources, and navigation. The study also included a site visit to James Island on June 26, 2001 (2001 site investigation). Shallow water and submerged snags limited access to the interiors of the James Island remnants, and many parts of the island were only observed from a shallow-draft outboard power boat. However, MES was able to access the sandy spit connecting the northern and central remnants, and a portion of the interior of the northern remnant. All references to height refer to elevation above the visible waterline or land, as appropriate.

6.1 Existing Conditions and Habitat Description

James Island has a humid, continental climate. The three narrow remnant islands constituting James Island are oriented slightly east of true north in the mouth of the Little Choptank River. The Little Choptank River is a tidal creek, fed by relatively little freshwater inflow. The shoreline primarily consists of fringe marsh and forested areas ending in steep, eroded banks. Observations during the 2001 site investigation (Appendix A) indicate that the interiors of the remnants are mostly forested with some clearings scattered within the forested areas. The forested areas appear to consist primarily of evergreen trees such as pines and spruces mixed with some deciduous species. The northernmost remnant is the largest of the three, and its orientation to the Chesapeake Bay indicates that this remnant is likely to be subjected to most of the natural physical forces imposed on James Island. The shoreline of the northern portion of the remnant has the steepest eroded banks, with heights between 5-10 ft, and numerous snags fallen into the adjacent waters (Photo 3). The majority of the northern remnant's interior is forested. During the 2001 site investigation, a wet meadow

Photo 3. Eroded shoreline and snags on the northern remnant.

was found in the wooded area on the northeastern shore of the island. MES personnel investigated the meadow and found that it was inundated with approximately 1-3 inches (in) of fresh water, and further observed that the meadow had earthen berms on three sides. The meadow had no berm on its the eastern side; instead it was bordered by the eroded shoreline. The berms appear man-made, as they exist in straight lines and are set at right angles to each other. The meadow may have been a man-made pond that lost some of its water retention abilities as the eastern berm on the shoreline eroded.

The southeastern portion of the northern remnant consists of fringe marsh with banks approximately 1 foot in height. A sandy neck of land extends from this marsh, connecting the northern and central remnants. The neck has small ponds located on its northern and southern ends. Emergent wetland grasses were observed growing in the northern pond and submerged aquatic vegetation (SAV) was observed in the southern pond (Photo 4). The shoreline of the neck consists of sandy beaches, and beach grasses grow throughout the interior portions of the neck. The southern end of the neck is attached to the central remnant.

The central remnant appears primarily wooded and is the smallest of the three remnants. The western side of the remnant has eroded banks with elevations of 5-10 ft lined with fallen and submerged snags similar to the northern remnant. The banks on the eastern side are also steep and cut-in, but appear to have an elevation of 3-4 ft. Marsh areas occupy the southern and eastern shorelines of the central remnant. A duck blind was observed in a marshy area on the eastern side of the central remnant.

Photo 4. Emergent grasses growing in and around the northern pond on the sandy spit.

The southern remnant appears primarily occupied by wooded areas mixed with fringe marsh habitat; it is separated from the central remnant by a tidal gut. The northern tip is marshy with 3-foot banks; a small, low elevation, marshy island is located just off the northern tip of this remnant. The western side of the southern remnant has steep, banks, 5-8 ft in elevation, lined with submerged snags. A small clearing is visible in the woods along the southwestern shoreline. On the southern tip stands a few dead trees scattered through a marshy area with banks of approximately 3-4 ft in elevation.

6.1.1 Water Quality

James Island is located in the central portion of the bay where the salinity level can be classified as mesohaline. General salinity in the area is approximately 9-16 ppt, with a mean of 14-15 ppt (J. Boraczek, personal communication). Water quality conditions in the Chesapeake Bay area vary due to many factors including human and industrial activity, stream flow, land use upstream, and water usage. Aerial photographs show that localized turbidity plumes, appearing to be associated with tidal flows, currently extend outward from James Island, possibly affecting benthic habitat. The depths at the site are relatively shallow and anoxia is not expected to occur, as would be the case in deeper areas of the Bay in warmer months.

The State of Maryland Chesapeake Bay Water Quality Monitoring Program has monitored water quality throughout the Chesapeake Bay since 1984. One Monitoring Station EE2.2 is located in the mouth of the Little Choptank River, approximately one-mile northeast of James Island. Station EE2.2 is set in approximately 13 meters (m) of water, and samples were drawn from surface (0-1 m), middle (1-11 m), and bottom (11-13 m) depths. Tables 6.1 and 6.2 present Station EE2.2 surface water quality data from January 1996 to December 2000. Surface sample data was used for this report correspond with characteristics of the shallow waters within the concept areas.

In Table 6.1, monthly water temperature data reflects a typical seasonal pattern. Dissolved oxygen (DO) follows an expected pattern inverse to temperature, with lower DO concentrations in warmer months and higher concentrations during colder months. Reported minimum oxygen requirements for sensitive species is 5.0 mg/L (Funderburk, *et al.*, 1991), and DO levels do not dip below this level for any of the sample seasons. Salinity varied within and between the years represented, but this could be due to fluctuations in freshwater flowing out of the Little Choptank. Data on nutrients and productivity (chlorophyll *a*) are presented in Table 6.1 and 6.2. The data for chlorophyll *a* presented in Table 6.1 and the remaining nutrient data in Tables 6.1 and 6.2 did not exhibit marked seasonal patterns.

6.1.2 Sediment Quality

The Chesapeake Bay is located in the Atlantic Coastal Plain Physiographic Province and is underlain by sequences of clay, silt, sand, and gravel. These geologically unconsolidated sediments date from the Cretaceous, Tertiary, and Quaternary Periods. Sediments in the vicinity of James Island would be expected to be a mix of sand, silt, and clay. Due to the erosion of James Island, the soils of James Island are likely to be found to various degrees as a veneer over historical bottom sediments in the waters around the island, if they haven't been swept away by natural forces. However, the sediments in the waters around the island may also vary considerably from soil types of the remnant islands due to physical and hydrodynamic changes in the area over time. Soil borings were not conducted for this report.

Review of the 1997 National Resources Conservation Service (NRCS) Dorchester County soil survey indicates that the James Island remnants are dominated by soils in the Elkton, Honga, and Sunken series; a small area of soils from the Keyport series is on the northern remnant. Elkton soils dominate the northern remnant. They are classified as silty deposits that typically overlay layers of sands or fluviomarine sediments. The "B" horizon tends to be clayey; cores of Elkton soils from 10-40 in below the surface

Figure 6.1 Location of Water Quality Station EE2.2

Map of Mainstem and Tributary Monitoring Stations

Source: ***http://cobia.chesapeakebay.net/data/wqstations.html***

Table 6.1 Water Quality Variables at Station EE2.2 at Depth of 0.5m (from the surface)[1]

Sample Year	Season	Salinity (ppt)	Temp (C)	DO (mg/L)	TSS (mg/L)	pH	Chlorophyll a (ug/L)	Total Dissolved Nitrogen (mg/L)	Total Dissolved Phosphorus (mg/L)
1996	Winter[2] (Jan. '96-Feb. '96)	9.88	0.65	13.55	17.50	7.90	10.69	1.23	0.013
	Spring (March '96-May '96)	8.75	10.97	11.20	14.00	8.00	11.02	1.22	0.014
	Summer (June '96-Aug. '96)	9.11	25.93	7.43	13.67	8.07	9.48	0.82	0.013
	Fall (Sep. '96-Nov. '96)	10.71	17.48	9.00	18.25	8.06	12.55	0.87	0.015
1997	Winter (Dec. '96-Feb. '97)	8.34	2.73	12.50	15.40	7.90	14.14	0.75	0.021
	Spring (March '97- May '97)	8.86	12.52	9.92	12.14	7.88	5.99	1.22	0.018
	Summer (June '97-Aug. '97)	11.99	25.03	8.10	16.64	8.15	8.91	0.26	0.020
	Fall (Sep. '97-Nov. '97)	15.80	16.10	8.48	21.14	8.03	9.72	0.18	0.023
1998	Winter (Dec. '97-Feb. '98)	15.05	5.43	12.00	16.33	8.30	9.85	0.27	0.017
	Spring (March '98- May '98)	7.34	14.54	11.38	10.46	8.68	14.95	0.70	0.011
	Summer (June '98-Aug. '98)	9.61	25.78	7.82	8.41	8.08	9.98	0.48	0.013
	Fall (Sep. '98-Nov. '98)	14.56	19.26	8.32	7.48	8.00	7.69	0.44	0.015
1999	Winter (Dec. '98-Feb. '99)	17.22	4.90	10.65	6.60	7.85	4.69	0.43	0.011
	Spring (March '99- May '99)	13.26	12.60	9.53	7.10	7.93	4.44	0.52	0.009
	Summer (June '99-Aug. '99)	14.71	27.20	7.17	4.77	8.00	5.08	0.38	0.012
	Fall (Sep. '99-Nov. '99)	15.98	18.37	8.33	9.50	8.00	6.75	0.36	0.014
2000	Winter (Dec. '99-Feb. '00)	15.77	3.07	11.70	12.45	7.83	8.45	0.41	0.010
	Spring (March '00- May '00)	11.92	13.23	8.63	5.04	7.80	6.65	0.62	0.010
	Summer (June '00-Aug. '00)	10.76	25.90	7.40	6.14	8.13	12.13	0.42	0.013
	Fall (Sep. '00-Nov. '00)	14.80	14.93	8.43	6.37	7.97	5.31	0.37	0.014

[1]Data compiled from the Chesapeake Bay Program Water Quality Monitoring Database
[2]No December 1995 sample data was available, therefore, winter 1996 only reflects three months of sample collection data.

Table 6.1 (Continued) Water Quality Variables at Station EE2.2 at Depth of 0.5m (from the surface)[1]

Sample Year	Season	Particulate Phosphorus (mg/L)	Dissolved Organic Carbon (mg/L)	Particulate Carbon (mg/L)	Particulate Nitrogen (mg/L)	Ammonium NH4 (mg/L) (filtered)	Ortho-phosphate Phosphorus (mg/L) (filtered)	Nitrite NO2 (mg/L) (filtered)	Nitrate+Nitrite NO2+3 (mg/L) (filtered)	Silica (mg/L) (filtered)
1996	Winter[2] (Jan. '96-Feb. '96)	0.027	3.40	-	-	0.080	0.013	0.008	0.710	0.82
	Spring (March '96-May '96)	0.016	3.53	-	-	0.025	0.009	0.017	0.675	0.26
	Summer (June '96-Aug. '96)	0.025	3.93	-	-	0.040	0.006	0.006	0.101	1.24
	Fall (Sep. '96-Nov. '96)	0.028	4.24	-	-	0.057	0.012	0.018	0.087	0.69
1997	Winter (Dec. '96-Feb. '97)	0.017	3.62	-	-	0.008	0.006	0.008	0.377	1.31
	Spring (March '97- May '97)	0.007	4.68	-	-	0.039	0.007	0.009	0.495	0.81
	Summer (June '97-Aug. '97)	0.016	4.39	-	-	0.104	0.006	0.004	0.054	0.51
	Fall (Sep. '97-Nov. '97)	0.021	3.88	-	-	0.190	0.011	0.002	0.006	0.23
1998	Winter (Dec. '97-Feb. '98)	0.012	4.72	-	-	0.071	0.008	0.006	0.071	0.10
	Spring (March '98- May '98)	0.012	4.10	2.44	0.27	0.014	0.003	0.008	0.457	0.26
	Summer (June '98-Aug. '98)	0.023	4.59	1.76	0.31	0.039	0.005	0.004	0.073	1.36
	Fall (Sep. '98-Nov. '98)	0.015	4.37	1.19	0.21	0.008	0.005	0.003	0.011	0.67
1999	Winter (Dec. '98-Feb. '99)	0.010	4.20	0.79	0.14	0.021	0.002	0.002	0.016	0.11
	Spring (March '99- May '99)	0.010	4.11	1.16	0.18	0.017	0.003	0.005	0.197	0.08
	Summer (June '99-Aug. '99)	0.013	4.08	1.19	0.20	0.004	0.003	0.001	0.006	0.34
	Fall (Sep. '99-Nov. '99)	0.013	4.28	0.83	0.15	0.010	0.003	0.002	0.006	0.10
2000	Winter (Dec. '99-Feb. '00)	0.015	4.14	1.57	0.23	0.005	0.002	0.003	0.047	0.09
	Spring (March '00- May '00)	0.015	4.02	1.31	0.22	0.089	0.004	0.006	0.207	0.29
	Summer (June '00-Aug. '00)	0.025	4.74	1.87	0.35	0.005	0.003	0.001	0.011	0.83
	Fall (Sep. '00-Nov. '00)	0.012	4.01	0.85	0.15	0.004	0.002	0.004	0.009	0.18

[1]Data compiled from the Chesapeake Bay Program Water Quality Monitoring Database
[2]No December 1995 sample data was available, therefore, winter 1996 only reflects three months of sample collection data.

generally contain 27-45% clay. Keyport soils constitute part of the shoreline of the northern remnant; these soils originate from clayey eolian deposits or fluviomarine sediments. Keyport soils tend to contain 30%-50% clay 15-48 in below the surface. Sunken and Honga soils are the prevalent soils on the central and southern remnant islands. Sunken soils are typically located on brackish submerged uplands; the amount of clay in these soils is less than Keyport, Elkton, or Honga. An average of 18-35% clay is found in the subsurface layer between 18-38 in. Honga soils are commonly found in tidal marshes, and are 15%-35% clay 22-36 in below the surface. The silt and high clay concentration features of the Honga, Elkton, Keyport, and Sunken soils of James Island are expected to be found in the shallows adjacent to James Island.

During the 2001 site investigation, observations were made regarding the character of the sediments adjacent to the sandy neck joining the northern and central remnants. On the western side of the neck, an approximately six-inch layer of sand covered a dark layer of clayey sediments. On the eastern side of the island, a thin layer of sand covered dark silty sediments for approximately 10 ft from the shoreline; beyond 10 ft the dark silty sediments were not covered by sand and the surface became silty/clayey and dark in color.

Sediments serve as a sink and a source for natural materials, as well as contaminants that bind to fine particulates that may be deposited and buried within sediments. Disturbance through construction, dredging or storm events can re-mobilize contaminants and particulates from the sediment into the water column. Any contaminants contained in terrestrial sediments that have eroded into the Bay around James Island may still be bound to local sediments. A review of sediment quality data reports did not find any sampling for this particular area. A geotechnical investigation would be needed to ascertain foundation conditions. Influences on sediment quality would be expected to include agricultural runoff, and stormwater runoff from residential or commercial areas in the region.

6.1.3 Fisheries and Aquatic Life

Many finfish and shellfish species support valuable commercial and recreational fisheries in the Chesapeake Bay. The Bay also supports a diverse fish community beyond those recognized as commercial or recreational resources. A list of finfish species that are likely to occur in the vicinity of James Island (i.e. mesohaline waters of the Bay) is presented in Table 6.3. Species that spend their entire life cycle in the Bay are included as well as migratory species and species only occasionally encountered in the Bay. The list includes such important commercial species as striped bass and white perch that are discussed further below in Sections 6.1.10.

During the 2001 site investigation several aquatic species were observed utilizing the waters around James Island. Several cow nose rays *(Rhinoptera bonasus)* were sighted around James Island; most of the sightings were concentrated on the eastern side of the island where the SAV beds were present. Schools of minnows were observed in the waters off of the eastern side of the neck. Both sea nettles (*Chrysaora quinquecirrha*) and moon jellyfish (*Aurelia aurita*) were also observed around James Island. Horseshoe crab (*Limulus polyphemus*), blue crab (*Callinectes sapidus*), razor clam (*Tagelus plebius*), and oyster shells (*Crassostrea virginica*) were seen on the sandy neck.

Table 6.3 General Distribution of Finfish in Mesohaline waters of the Chesapeake Bay						
Common Name	Full Time Resident	Season				Occasional
		Fall	Winter	Spring	Summer	
Bull shark						J, A
Sandbar shark						J
Cownose ray					J, A	
Shortnose sturgeon						J, A
Atlantic sturgeon						J,A
American eel				L, J		A
Blueback herring		J	J	J, A	J, A	
Hickory shad						J, A
Alewife		J	A	J, A	J, A	
American shad			A	J, A	J, A	
Atlantic menhaden		A, L	J	E, L, A	J, A	
Atlantic herring			A	A	J, A	
Gizzard shad						J, A
Threadfin shad						J, A
Striped anchovy						J, A
Bay anchovy		E, L, J, A	J, A	E, L, J, A	E, L, J, A	
Chain pickerel						J, A
Inshore lizardfish						J, A
Oyster toadfish	X					
Skilletfish	X					
Halfbeak						J, A
Atlantic needlefish		J, A		E, A	E, L, J, A	
Sheepshead minnow	X					
Banded killifish						J, A
Mummichog	X					
Striped killifish	X					
Rainwater killifish	X					
Rough silverside						J,A
Inland silverside	X					
Atlantic silverside	X					
Fourspine	X					
Stickleback						
Threespine	X					
Stickleback						
Lined seahorse	X					
Dusky pipefish						J, A
Northem pipefish	A					
Northem searobin						J, A
White perch						J, A
Striped bass	X (J)					
Black sea bass						J, A
Yellow perch						A
Bluefish		J,A		J,A	J,A	
Cobia						J, A
Blue runner						J, A
Crevalle jack						J, A
Lookdown						J, A
Florida pompano						J, A
Scup						J, A
Silver perch						J, A
Spotted seatrout		J		J	J, A	
Weakfish		J		L,J	L, J A	
Spot		J		J	J, A	
Atlantic croaker		J		J	J, A	

Table 6.3 General Distribution of Finfish in Mesohaline waters of the Chesapeake Bay (Continued)						
Common Name	Full Time Resident	Seasonal				
		Fall	Winter	Spring	Summer	Occasional
Black drum		J			J, A	
Red drum		J				
Striped mullet						J, A
White mullet						J, A
Northern stargazer						A
Striped blenny	X					
Feather blenny	X					
Darter goby						J, A
Naked goby	X					
Seaboard goby						J, A
Green goby	X					
Spanish mackerel						J, A
Harvestfish						J, A
Butterfish						J, A
Summer flounder		J, A		J, A	J, A	
Windowpane						J, A
Winter flounder		A	A, L	L, J	J	
Hogchoker	X					
Blackcheek						J, A
Tonguefish						
Northern puffer						J, A
Striped burrfish						J, A

For all of Table 6.3:
Resident= non-mobile, habitat specific; Seasonal= pelagic migratory; Occasional= limited by salinity or habitat, occurrence unlikely.
Lifestages: E=Egg; L=Larvae; J=Juvenile; A=Adult, X= All Lifestages Resident
Sources: Hildebrand and Shroeder 1928; Lippson and Lippson 1984; Lippson 1973, EPA EMAP database (1995), Heck & Thoman 1984, Murdy et al. 1997. EA Eng., Sci. & Tech., Inc. PI-15 Parsons Draft Final: OS/10/O1

Essential Fish Habitat (EFH)

The National Marine Fisheries Service (NMFS) website was used to assess essential fish habitat (EFH) in the habitat restoration project concept areas. According to NMFS, James Island is located in an area that may provide EFH to seven species: summer flounder *(Paralicthys dentatus),* windowpane flounder *(Scophthalmus aquosus)*, bluefish *(Pomatomus saltatrix),* cobia *(Rachycentron canadum),* red drum *(Sciaenops ocellatus),* king mackerel *(Scomberomorus cavalla)*, and Spanish mackerel (*Scomeromorus maculatus)* (www.nero.nmfs.gov). Some inferences about the potential for essential fish habitat can be derived from existing literature and observations made during the 2001 site investigation. A general analysis of impacts on each species is included in Section 6.9. Consultations with NMFS may be necessary if further studies of the habitat restoration project are considered.

6.1.4 Benthos

The benthic community represents an important ecological component in the Chesapeake Bay ecosystem. Benthic species serve as food to many higher organisms, including finfish, blue crabs and some species of waterfowl. Some animals, such as the soft-shell clam (*Mya arenaria)*, razor clams *(Ensis directus and Tagelus plebius)*, and American oysters *(Crassostrea virginica)*, are also important commercially as well as ecologically.

MDNR conducts a benthic monitoring program using long term monitoring of fixed sites and summertime sampling of randomly selected sites throughout the Bay. The closest fixed site monitoring stations to James Island are Stations #004 and #005, which are 4.3 and 3.7 miles away from James Island, respectively. Neither station has been sampled since 1989. Station #004 is located in approximately 60 ft of water. Due to the lack of recent data, and the apparent deep-water habitat characteristics of Station #004, data from the fixed stations were not used in this report. The benthic monitoring program sampled two randomly selected sites in the vicinity of James Island in 1999 and 2000, respectively. The 1999 site is located in the shallows off of the northeast site of the northern remnant, and the 2000 site is located in approximately 15 ft of water 1 ¼ mile northeast of James Island.

The Benthic Index of Biologic Integrity (B-IBI) was used to assess the health of the 1999 and 2000 sample sites. The B-IBI score of 1 through 5 (5 being healthiest) was broken down into rankings of severely degraded, degraded, marginal, and meets goal. B-IBI scores of less than or equal to 2 were ranked as severely degraded, 2.1 to 2.6 as degraded, 2.7 to 3 as marginal, and scores higher than 3.0 were considered to meet the restoration goals. The 1999 sample, which was obtained from the shallows northeast of James Island, received a score of 2.33 on the B-IBI, ranking the sample site as degraded. The year 2000 sample also received a score ranking the site as degraded (between 2.1 and 2.6), but the exact B-IBI score was not available for that year. Low scores on these recent B-IBI tests indicate a limited benthic community in the sediments around James Island.

During the 2001 site investigation of James Island, stout razor clam and oyster shells were found on the beach. Other shell fragments were present along the beach, but were not identified. The presence of razor clam shells and other shell fragments along the shores of James Island may indicate the existence of some kind of benthic community in the sediments around James Island.

6.1.5 Submerged Aquatic Vegetation (SAV) and Shallow Water Habitat

Submerged Aquatic Vegetation (SAV) has historically declined over most of the Bay. These declines may be due, in part, to high turbidity and nutrient loading. The Virginia Institute of Marine Science (VIMS) produces SAV bed location maps by conducting annual surveys using aerial photographs based on USGS 7.5-minute quadrangles followed by ground-truthing to monitor the SAV population. James Island and its immediately surrounding waters lay on the Hudson, Maryland and Taylors Island USGS 7.5 minute quadrangle maps. SAV maps for 1994 through 2000 were reviewed for this conceptual study.

The 1994 to 1998 VIMS SAV maps show no SAV beds located around James Island; the closest SAV beds in these years were adjacent to the northeastern shores of Taylors Island, one mile south of James Island. However, the 1999 map shows SAV beds along the eastern shore of James Island. Ground-truthing by the Environmental Protection Agency found two SAV beds adjacent to the eastern side James Island that are reported on the 1999 VIMS map. One SAV bed adjacent to the southern James Island remnant had a recorded plant density of 0-10% and a recorded area of 16,611 square meters. The second SAV bed, located between the central and northern remnant, had a reported plant density of 10-40% and a reported area of 56,494 square meters. Both beds were reportedly dominated by widgeon grass *(Ruppia maritima)*. The 2000 SAV map shows no SAV beds adjacent to James Island. None of the VIMS SAV maps from 1994 to 2000 noted SAV beds within the beneficial use concept area.

SAV beds were observed on the eastern side of James Island during the June 2001 site investigation. Samples taken from these beds were identified as eelgrass *(Zostera marina).* These SAV beds appeared to be low density and present along the entire eastern shore of the sandy neck and most of the northern remnant. Observations from the 2001 site investigation did not indicate the presence of SAV beds in the proposed concept areas.

The eastern side of James Island is more protected than the west side and has depths of less than two meters near shore. The historical background erosion rate for the eastern side of the remnants has been very small. Although these conditions would seem to be favorable to SAV growth, the eastern side of the remnants experience considerable turbidity due to erosion of the island.

6.1.6 Terrestrial Vegetation

Observations from the 2001 site investigation indicate that James Island is primarily forested. The forested areas consist of mostly evergreen trees and some deciduous trees with a shrub understory; loblolly pines (*Pinus taeda*) appear to dominate the observed areas. Small clearings in the woods on James Island were visible during the 2001 site investigation. One clearing, the bermed wet meadow on the northern remnant, was investigated during the 2001 site investigation. Loblolly pines grew around the berms. The interior of the meadow appeared dominated by tall beak-rush *(Rhynchospora macrostachya)* an obligate wetland plant.

The dominant plant species on the sandy neck between the central and northern remnants were identified as common reed *(Phragmites australis)*, smooth cordgrass (*Spartina alterniflora*) and salt meadow cordgrass *(Spartina patens).* Common reed and salt meadow cordgrass are wetland species classified as facultative wet. Smooth cordgrass is classified as an obligate wetland species. Common reed is an invasive species that is subjected to control measures in regional marshes; however, common reed appeared to be confined to central areas of the sandy neck with salt meadow cordgrass dominating the remaining dune tops. Smooth cordgrass was present on the lower beach areas. Marshy areas were also observed on some shoreline areas of the southern and central remnants. Common reed did not appear to inhabit these marshes; they appeared occupied by a low marsh species such as salt meadow cordgrass.

6.1.7 Wetlands

Review of the 1985 Hudson, Maryland National Wetlands Inventory Map (NWI map) shows several wetland areas on the remnant islands. Estuarine, emergent, intertidal wetlands are reportedly located on the southern and northern tips of the remnant islands, and portions of the eastern shoreline of the southern remnant; aerial photography also suggested the presence of wetlands on these areas. The NWI map classifies the sandy neck between the northern and central remnants as an irregularly flooded beach/bar habitat. The presence of the reported wetland areas on the shoreline of the remnants and central spit was confirmed during the June 2001 site investigation.

Two interior wetland areas are noted on the NWI map. An evergreen/ scrub shrub emergent wetland is noted on the southern remnant, and an area of open water with unknown or unconsolidated bottom is recorded on the northern remnant. The mapped location of the open water with unknown/ unconsolidated bottom sediments on the NWI map appears to coincide with the location of the bermed wet meadow on the northern remnant. The bermed wet meadow appears to have formerly been a completely bermed pond; as of the 2001 site investigation, the eastern portion of the berm was absent and obligate wetland plants grew in the area within the berm which remains inundated.

The NRCS Soil Survey map of Dorchester County classifies some areas on the central and southern remnants as having Sunken Mucky Silt Loam soils, indicating the presence of hydric soils; this seems to contradict the NWI map designation for those areas as upland. Sunken Mucky Silt Loam soils are indicative of brackish submerged uplands. The presence of Sunken Mucky Silty Loam soils on areas that the NWI map classifies as upland may indicate that some wetlands may be present on James Island that are not reported on the NWI map.

Review of the NWI map and USDA Soil Survey of Dorchester County indicate that James Island contains several shoreline and inland wetlands. The 2001 site investigation confirmed the presence of the shoreline wetlands and an interior wetland on the northern remnant. No identified wetlands are present within the borders of the proposed concept areas, because the concept areas are not attached to James Island.

6.1.8 Birds/ Wildlife

According to Funderburk, *et al.*, James Island is potential wintering habitat for the American black duck *(Anas rubripes)*, canvasback *(Aythya valisineria)*, and redhead *(Aythya americana)*; the island is within the confirmed nesting area of osprey *(Pandion haliaetus)*. Additionally, Funderburk, *et al.* reports the probable presence of one or more green backed heron *(Butorides striatus)* nesting sites on Taylors Island between 1982 and 1989. Confirmation of the nesting sites on Taylors Island was not available, but if Taylors Island has supported green backed herons, it is possible that James Island might also support green backed herons.

Two duck blinds were observed on James Island during the June 2001 site investigation. One blind was located offshore of the eastern side of the central remnant, and was not closely inspected. The second duck blind was located in a marshy area of the central remnant; permit numbers were posted outside of this blind. The presence of the duck blinds suggests that James Island is wintering habitat for waterfowl of interest to hunters.

According to the MDNR, James Island is a likely home to bald eagles, osprey, migrant songbirds, small mammals, black ducks, mallards, roosting blue herons, terrapins, and muskrats. Otters may possibly live on the island, but the mammal population of James Island should be limited by its offshore location. Canada geese may also utilize the shoreline of the James Island, but the island itself seems to lack the open fields geese typically utilize on land (Glenn Therres, pers. comm., September 12, 2001).

During the June 2001 site investigation a blue heron *(Ardea herodias)*, several osprey, a red tail hawk (*Buteo jamaicensis*), and two bald eagles *(Heliaeetus leucocephalus)* were observed utilizing James Island and the surrounding waters. Nests were observed in the tops of dead trees on the shorelines of the southern remnant and the central remnant. The nest on the southern remnant is believed to be an osprey nest, as an osprey was observed sitting on a branch next to it, and the nest appeared smaller and built in a shorter tree than would be typical of a bald eagle's nest. The nest on the central remnant appeared to be in poor condition; its size and condition suggested it was an osprey nest that may no longer be in use. Although two bald eagles were observed perched in trees on and flying over James Island, no nests appearing to have the characteristics of a bald eagle's nest were observed.

According to Broughton Earnest, attorney for the owners of James Island, sika deer (*Cervus nippon*) were introduced to James Island in the 1930's. From the James Island herd, sika deer eventually colonized other shoreline areas near the island (B. Earnest, pers. comm., June 25, 2001). During the 2001 site investigation, deer tracks believed to be from sika deer were observed on the sandy neck. Other evidence of inhabitant species observed during the site investigation include the remains of a diamondback terrapin (*Malaclemys terrapin*) found on the beach, and a turtle nest with egg shell fragments located near the site of the diamondback turtle carcass.

6.1.9 Rare, Threatened, and Endangered Species

Bald eagles are listed as a Federal Endangered Species, and two were observed flying over and perched in trees on James Island during the 2001 site investigation. No bald eagle's nests were observed on James Island, but nests may be located in the un-inspected interior of the island, or bald eagles may use James Island for hunting. Coordination with DNR and the USFWS would be appropriate for higher level studies on the potential of James Island for a beneficial use of dredged material project.

Recently, the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have cited shortnose sturgeon (SNS) *(Acipenser brevirostrum)*, a Federally listed endangered species, as a concern within the Bay. USFWS also has expressed concerns about wild Atlantic sturgeon *(Acipenser oxyrhynchus)*, which has been recorded in the Bay as a species of concern but is not listed as a federally endangered species. In 1996, USFWS initiated a Reward Program for incidental catches of sturgeon in commercial gear. Data for 1996 through March 2002 provided by MDNR reports no SNS catches within 3.5 miles of James Island. The same MDNR data reports five catches of Atlantic Sturgeon in the vicinity of James Island: two catches approximately 0.7 and 2.0 miles east of the island, respectively; one approximately 2.5 miles northwest of the island; and two approximately2.5 and 3.5 miles west of the island. No reported Atlantic sturgeon catches were within any of the proposed alignments; however, consultation with MDNR, USFWS, and NMFS may be necessary during proceeding studies for the beneficial use project.

6.1.10 Commercial Fishery

The Chesapeake Bay and Little Choptank River support commercial fishing for oysters, soft-shell clams, blue crabs, and finfish. The National Oceanic and Atmospheric Administration (NOAA) and the Maryland Department of Natural Resources (DNR) have separated the Chesapeake Bay into zones and maintain catch statistics for commercial fisheries in each zone. These statistics consist of the tonnage and economic value of the commercial hauls for the Chesapeake Bay by zone number. James Island is located on the boundary between two zones; the Little Choptank River is Zone 053, and the mainstem Chesapeake Bay west of James Island is designated Zone 027 (Figure 6.1). The Chesapeake Bay zone is to the west of James Island and includes data from the entire mainstem bay from the Little Choptank River north to the Bay Bridge. The commercial statistics and the haul information for each of these zones are presented in Tables 6.4 and 6.5.

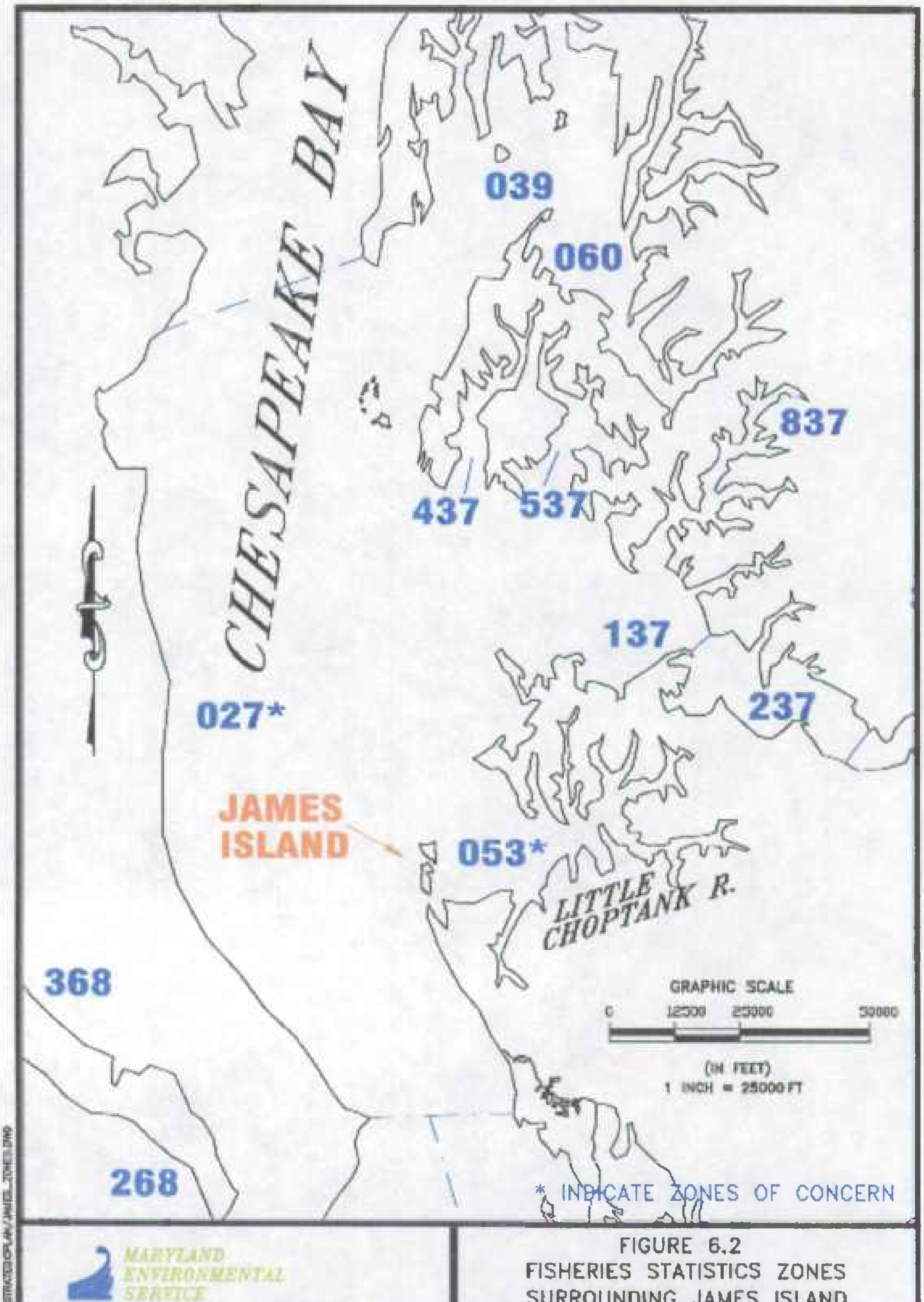


FIGURE 6.2
FISHERIES STATISTICS ZONES
SURROUNDING JAMES ISLAND

Table 6.4 Commercial Landings from the Mainstem Chesapeake Bay (NOAA zone 027)[1]

Species	1995		1996		1997		1998		1999		2000	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Blue crab, hard	7949893	6662148	6570675.4	4517427	9199809.2	6753100	5944930.6	5589173	6549544.3	5331922	4147616	4392142
Blue crab, soft	91049	259598	92512.52	400848	78832.36	370106.2	82657.5	390821.9	80437.44	424869.3	63593	336558
Clam, soft	8556	583864	7575	412045	7718.25	589089	9436.38	772777.4	5427.38	433067.5	6907	504617
Oyster	24366	86312	74558	204633	125483	446281	89142	300554	351286	1087050	95584	300779
Bluefish	5770	2716	10139	2085.85	3738	1239.2	5472	1700.92	2967	893.14	2297	412
Channel catfish	—	—	2728	1579.2	6743	2063.51	12140	5779.4	1000	304	20	8
Croaker	2481	1218	16413	6007.62	30360	10371.14	33075	12385.91	13742	4843.28	59166	18708
Eel	3000	7820	3116	625.09	18841	9208.05	3726	7855.74	15520	20921.68	4000	4320
Summer Flounder	175	273	1519	2669.03	3644	7422.4	1597	3046.09	503	1040.45	2006	3220
Menhaden	1227724	125240	941400	94772.55	706982	68645.03	498096	45680.08	1216108	99620.53	900817	107813
Gray sea trout	1030	903.8	1604	1661.51	2117	1390.67	1788	1157.42	2038	1380	6207	2430
Spot	9028	3469	2366	1451	856	503.62	3033	1314.78	1712	834	17057	8375
Striped bass (released)	19577	0	61081	0	25134	0	52842	0	9382	0	6531	0
Striped bass	323294	492008	330424	509324	571717	815780.2	588501	776522	595716	936768	769376	1154070
Herring	160	19	—	—	96	17.85	1100	121	—	—	—	—

Table 6.5 Commercial Landings from the Little Choptank River (NOAA zone 053)

Species	1995		1996		1997		1998		1999		2000	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Blue crab, hard	1076134	1080107	1069094	997592	1067648	977539	976947	1018697	1103349	1236273	466136	594917
Blue crab, soft	17559	48163	19175	81330	11002	50658	10512	47545	24072	123629	9582	50363
Clam, soft	—	—	—	—	—	—	—	—	—	—	—	—
Oyster	123528	382880	12157	29324	260894	844179	231107	681506	538094	1462730	214790	606683
Bluefish	269	130	637	319	2755	1206	537	170	246	60	—	—
Channel catfish	—	—	107	62	—	—	50	21	—	—	—	—
Croaker	1973	1049	21065	8510	6638	2267	9908	3914	832	271	175	61
Eel	4838	10403	14739	5476	8386	4612	927	1994	3070	4720	2374	2993
Summer Flounder	1221	2276	2025	3293	657	1380	1274	2632	288	617	—	—
Menhaden	133680	13047	91830	9227	58990	5849	4720	479	5070	420	75	8
Gray sea trout	38	53	61	92	190	95	275	186	143	104	—	—
Spot	199	88	356	180	89	55	11	6	—	—	—	—
Striped bass (released)	—	—	—	—	160	0	130	0	—	—	150	0
Striped bass	4032	6115	5078	9182	5607	6398	10673	14330	5219	8075	7821	11035
Herring	—	—	—	—	—	—	—	—	—	—	—	—

[1] This area, Zone 27, consists of the mainstem bay from the Little Choptank River north to the Chesapeake Bay Bridge

Source: DNR commercial fisheries website, www.dnr.state.md.us/fisheries/commercial.

Oysters

The State of Maryland has catalogued by number and designated boundaries for its "natural oyster bars" (NOBs), and regulates the activities within these boundaries. MDNR provided the boundaries and coordinates for NOBs in the vicinity of James Island (Figures 2.1-2.5). Three natural oyster bars are located in the vicinity of James Island. The Hills Point North and Hills Point South bars (NOB 14-5) are located approximately 5000 ft (1520 m) north of James Island in the Chesapeake Bay. The Hooper Cove/ Slaughter Creek bar (NOB 15-2) is located approximately 1500 ft (450 m) east of James Island, in the Little Choptank River. The Granger/ Catoṙs Cove bar (NOB 14-6/15-1) is located at the mouth of Oyster Cove approximately 1000 ft (300 m) southeast of James Island. Harvest data for the three NOBs in the vicinity of James Island is included in the Little Choptank River data from Table 6.5. Revenue from the commercial oyster harvest in the Little Choptank River topped one-half million dollars in 1997, 1998, and 2000. In 1999 the Little Choptank River oyster harvest was worth over one million dollars. The totals from Table 6.5 indicate that the Little Choptank River oyster bars compose a significant fishery, and it is probable that NOB 14-5, NOB 15-6, and NOB 15-1 make significant contributions to this fishery.

Alignments 3, 4, and 5 are closest to NOB 14-5; all three dike alignments end approximately 900 ft (270 m) south of NOB 14-5 (Figures 2.3, 2.4, 2.5). Alignment 2 is closest to NOB 15-2 (Figure 2.2); it extends eastward across the northern shallows of James Island, and ends approximately 750 ft (230 m) away from the NOB. Alignment 1 (Figure 2.1) is the smallest dike configuration; it is approximately 3000 ft (900 m) away from NOB 14-6/15-1 at its closest point to any NOB. All dike alignments are at least 700 ft (230 m) from any recorded NOB; however, consultations with DNR regarding dike positions relative to NOB boundaries would be appropriate for future studies.

Soft Shell Clams

The soft-shell clam *(Mya arenaria)* represents a significant fishery in the mesohaline portion of the Chesapeake Bay. Soft shell clams can be found in relatively shallow waters, with sandy or other soft substrates. James Island is in the middle of the mesohaline portion of the Bay, and there is a soft-shell clam fishery in the Bay waters west of James Island (Zone 27), which produced 6,907 pounds in 2000 (Table 6.4). Soft-shell clams have no reported commercial landings from the Little Choptank River (Table 6.5), and therefore are not likely to be a significant fishery in that region. Surveys rated the benthic community in the vicinity of James Island as "degraded" (Section 6.1.4) and during the 2001 site investigation no soft clam shells were found on the beach. The lack of fishery statistics and a poorly developed benthic community indicate that it is not likely the waters within the proposed concept areas or around James Island support a soft shell clam fishery.

Blue Crabs

The blue crab supports the dominant commercial fishery in the Chesapeake Bay. James Island is surrounded by shallow water with scattered SAV beds on the eastern side, a favored summertime blue crab habitat, and James Island is located in a recorded high-density area for summertime male blue crab residence. James Island is also just outside of the reported northern extent of the high-density female summertime range (Funderburk, *et al.*).

The waters around James Island support both hard and soft crabbing industries. The Little Choptank River (Zone 53) produced over 400,000 pounds of commercial hard crabs, and Zone 27 produced over four million pounds of commercial hard crabs in the 2000 season (Tables 6.4 and 6.5, respectively). Hard crab catches prior to 2000, for 1995 to 1999, produced approximately one million pounds per year. The Chesapeake Bay catches in Zone 27 ranged between approximately 5 and 10 million dollars for the years 1995 through 1999. These statistics indicate the presence of a viable blue crab fishery around James Island. During the June 2001 site investigation, commercial crab pot fields were located at each the northern and southern ends of James Island; all five proposed dike alignments could extend into the crabbing areas.

Finfish

The catch tonnage and revenue very widely between 1995 and 2000. Data in Table 6.5 indicate that striped bass, menhaden, eel, and croaker are the most productive fisheries in the Little Choptank River (Zone 27). Gray sea trout, summer flounder and bluefish also help support commercial fisheries; the spot and channel catfish fisheries appear to be declining in productivity in the Little Choptank. The most significant finfish fisheries in Chesapeake Bay waters west and north of James Island (Zone 53) consist of croaker, menhaden, spot, and striped bass (Table 6.4).

The Little Choptank River is reported to be part of the potential distribution range of white perch, which is also fished commercially (Funderburk, *et al.*). As James Island is located in the mouth of the Little Choptank River, it is probable that on occasion it is within the range of the white perch habitat due to seasonal and yearly variation in habitat characteristics; however, no catch statistics for this fishery were available. Due to the shallows, it is believed that commercial fishing is limited in the waters immediately around James Island and the proposed concept areas. No commercial fishing vessels or nets were observed in the proposed concept areas or the waters around James Island during the 2001 site investigation.

6.1.11 Recreational Resources

James Island is privately owned; it is not open to the public as a park. The owners and their guests use the island for hunting, fishing, and other recreational purposes. Two duck blinds in good repair were observed on or near James Island during the 2001 site investigation. One duck blind was located on the eastern side of the central remnant and had permit numbers posted on-site. The second duck blind was located in the waters just east of the sandy neck between the northern and central remnant; this blind was not inspected for the presence of permit numbers. Anecdotal evidence tells of further hunting and fishing uses on the island, such as the 1930's release of sika deer on the island (Broughton Earnest, Esq., pers. comm.). Although the island is accessed for hunting and fishing, the shallow waters and snags surrounding it may limit its popularity as a destination for recreational boaters. Anecdotal information indicates that recreational kayakers may occasionally use the area. A charter captain also reported that recreational fishing often occurs around James Island. A popular recreational fishing destination is located well offshore to the west of James Island where there is a sharp drop into the deeper waters of the Chesapeake Bay (W. Young, 1999).

6.1.12 Historical Resources

According to the original patents, the Killman and Patterson families originally settled James Island during or prior to the 1800's. The Armstrong family later acquired portions of James Island; the northeastern portion was named Armstrong's Folly, and the southern section was known as Armstrong's Hog Pen. Armstrong's Hog Pen is reported to be under water. The Patterson family owned the central part of James Island into the 1800's; they had their seat at "The Grove" located on what is now the southern James Island remnant (W. Young, 1999).

During the site visit shards of glass, brick, and pottery were found along the beach between the northern and southern remnants; these pieces could be archeological artifacts from the households that inhabited the island. A literature search at the Maryland Historic Trust (MHT) in Crownsville, Maryland revealed four recorded archeological sites along the eastern shore of the remnant islands. One site is located either on or submerged beside the neck connecting the northern and central remnant; one site is located on the shoreline of what is now the central remnant; the remaining two sites are located along the shoreline of the southern remnant. None of the recorded archeological sites appear to be located within the proposed concept areas. The literature review at the MHT revealed no standing structures on James Island that have been recorded or nominated as eligible for listing on the National Register of Historic Places. No standing structures were observed on James Island during the June 2001 site investigation. It is not known if any events, people, or places of historic significance are connected with the island, but further consultation with the MHT regarding the archeological sites may be appropriate for higher level studies.

6.1.13 Groundwater

The predominant aquifer systems in Maryland consist of the Chesapeake Group (Eastern Shore only), the Aquia Group (including the Aquia and Piney Point-Nanjemoy subaquifers), the Severn-Magothy Aquifer, and the Potomac Group (including the Patapsco and Patuxent subaquifers). Confining layers, usually of clay or fine sand, separate these aquifers.

The Aquia Aquifer generally subcrops (is exposed below the water surface) beneath a thin veneer of Pleistocene sediments, and crops out as bluffs along the banks of rivers and creeks. In some places, the upper confining bed is absent and the Aquia Aquifer subcrops or there is direct contact between, the Aquia and the overlying unconfined aquifer known as the Piney Point Aquifer (the other major aquifer of the group). In deeper areas (i.e., the old paleochannel), the Aquia Aquifer is in contact with highly permeable channel deposits, which are then overlain by fine-grained deposits rich in organic material. According to Drummond (1988), the fine-grained, lower permeability Bay-bottom sediments, which in places separate the Aquia from the Chesapeake Bay, are also part of the upper confining bed.

The Piney Point Aquifer, an Eocene aged sub-aquifer in the Aquia Group, is the primary groundwater source for the city of Cambridge and southern Dorchester County, including James Island. The Piney Point Formation (Section 3.0) of the Eocene age contains the Piney Point Aquifer, which is the main source for drinking water for the southern portion of Dorchester County including James Island. The Piney Point Aquifer occurs at depths between 300 to 400 ft in the vicinity of James Island. Due to increased pumping, water levels for this productive aquifer have decreased throughout the entire area since the late 1970's. In areas near the Choptank River and surrounding tidal areas, the water can have high levels of hydrogen sulfides and may require treatment prior to use (Dorchester County Soil Survey).

6.1.14 Aesthetics and Noise

A literature review of the inventory of historic properties at the MHT in Crownsville, Maryland revealed four State and/or federally listed historic properties on Taylors Island that are potentially eligible for listing on the National Register of Historic Places (NRHP). Historic sites listed or considered eligible for listing on the NRHP are sometimes protected from aesthetic impacts to their viewsheds. One historic residence, a farm named Patrick's Discovery located on the shore of Taylors Island, appears to have a direct sight line to the southern tip of James Island and possibly the southern portion of the proposed concept areas. Oyster Creek Farm, a private residence located on Taylors Island, may also have a view of James Island and the proposed concept areas. Mulberry Grove is a residence and historic farm located on the highest point near the shore of Taylors Island, is due south of James Island, and may have a view of the proposed concept area. Bethlehem Methodist Episcopal Church is a 19th century church located inland, and James Island and the concept areas are not likely to be visible from this location. It is not believed that construction of the habitat restoration area would be significantly visible from these locations due to the distances of the identified historic properties from James Island. However, the historical viewshed would have included the prior landmasses of James Island that is now submerged. Further consultation with MHT may be needed on this issue.

Currently sound sources in the area around James Island come from predominantly natural sources. Anthropogenic sound sources can include passing recreational boaters or commercial fishermen and crabbers fishing the shallows. During the 2001 site investigation, noises from neighborhoods on Taylors Island were not audible on James Island. The viewshed from James Island consists of typical, residentially developed Chesapeake Bay shoreline.

6.1.15 CERCLA Liability

Preliminary evaluations of James Island and the proposed concept areas have indicated that no hazardous, toxic or radioactive substances exist within the project area. A search of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) database on-line (www.us.epa.gov) revealed three hazardous waste sites located in Dorchester County. The closest of the three CERCLA listed sites to James Island is located in Cambridge, which is 15 miles northeast of James Island. Due to the distance of the three identified sites from James Island, it is not likely they have impacted the island or the concept areas; therefore, no CERCLA liability is believed to be associated with the site.

6.1.16 Critical Areas

The Chesapeake Bay Critical Areas Commission (Title 27, Code of Maryland Regulations (COMAR)) designates all lands within 1000 ft of the mean high tide line or landward edge of adjacent tidal wetland as a "critical area". The width of the James Island ranges between 100 yd (90 m) and 400 yd (360 m) across. By the definition of critical areas, all of James Island is subject to Maryland Critical Areas regulations due to the distance of the island's interior from the shoreline. The proposed concept areas are also considered to be within the state defined Critical Areas, because they are located within the tidal waters and tributaries of the Chesapeake Bay. The Maryland Critical Areas regulations may not result in a significant concern since the activities related to construction of the dikes and placement will occur for a limited time period and the end result will be consistent with critical areas conservation intent.

6.1.17 Navigation

The proposed project area does not lie within or adjacent to any federal navigation projects or channels. The mainstem Bay channel is approximately 3 miles west of James Island. The shallow waters around James Island and the potential project site may limit navigational access to that area; however the shoaling and snags around James Island currently impede navigational access. Use of the site for the placement of dredged materials would support maintenance of regional navigation projects and help prevent further shoaling around the island.

There are anecdotal reports that small craft including commercial fishing vessels transit between the Little Choptank River and the mainstem Chesapeake Bay by traversing the shallows between Taylors Island and James Island. A restoration project could effect or block passage through this area.

6.2 Potential Impacts

6.2.1 Water Quality and Sediment Quality

Short-term impacts to water quality would be expected during construction. Water quality effects during the placement of dredged material would be minimized through regulatory controls of discharge water quality as with the Poplar Island Environmental Restoration Project. Construction impacts would be expected to include turbidity-related impacts only. Turbidity and pH effects would be monitored and coordinated with the appropriate regulatory agency as effluent from dredged material placement is discharged. Any effects from discharging into background waters would be localized and likely to consist of heightened suspended solids concentrations, fluctuations in pH, and elevated levels of nutrients. These effects would be short-term and regularly monitored for acceptable levels during all discharge events. The sediment being inflowed into the habitat restoration area would be considered clean, as only sediments from the main stem Bay (east of the North Point-Rock Point line in the Patapsco River) would be included in the project. No Baltimore Harbor sediments (from west of the North Point-Rock Point line) would be deposited into the beneficial use project. Therefore, there would be no negative impacts from contaminated sediments to water quality during discharge.

The sediments being inflowed into the habitat restoration area may also be of a different grain size and soil series than the native sediments. However, as the sediments will not be contaminated and the project will result in renewed habitat and protection from erosion for James Island, it is unlikely that different types of clean sediments would adversely affect the water or sediment quality. The proposed habitat restoration project should improve overall water quality in the vicinity of James Island by protecting the shoreline from further erosion and thereby reducing suspended solids in the water column. Additionally the project would reduce physical energy from the southwest, west, and northwest which would be anticipated to have ancillary shoreline protection benefits for some areas in Dorchester County.

6.2.2 Biological Resources

Habitat restoration construction on the concept areas would occur entirely in the water separated from the remnant islands and would not directly effect the vegetation and structure of the shoreline or inland habitats on James Island. Noise and activity from the construction may cause animals to avoid the areas of James Island closest to the construction, but these effects should diminish after construction of the dike enclosure is finished.

Although there have been no reported catches of shortnosed sturgeon within 3.5 miles of James Island, and no reports of Atlantic Sturgeon catches within the concept area, further consultations with NMFS and USFWS about SNS would be appropriate for higher level studies. During the 2001 site investigation, bald eagles were observed on and around James Island, but no evidence of an eagle's nest was found. Formal consultations for all RTE species would also be needed with NMFS, USFWS, and DNR if higher level studies were undertaken.

Of the 1994 through 2000 VIMS maps, only the 1999 VIMS survey reported SAV at James Island. The 2001 site investigation also located SAV on the eastern side of the island; however, all known VIMS maps and observations have placed SAV at James Island outside of the proposed concept areas. Construction of the habitat restoration area on the western side of James Island may increase turbidity for a short time period; however, once completed the project would help prevent further erosion of James Island, and promote SAV in the waters around the island by reducing concentrations of suspended solids in local waters due to erosion. Tidal channels in the wetland cells and the planned tidal between the project area and remnants should provide additional habitat potentially suitable for SAV growth.

Shells identified on the beaches of James Island indicate the possible presence of some kind of benthic community in the sediments around the island. Any benthics within the footprint of the concept area, between 978-2200 acres, would be lost at the time of construction; however, existing studies conducted from the shallows around James Island classify the benthic community in the area as degraded, so impacts should not be as great as in a more productive area (Llanso, 2001, and Llanso, 2000). The waters within the concept area are generally too shallow to be favored for wintering male blue crabs; however, any blue crabs that may be burrowed in the sediments over wintering in the footprint would be lost if construction occurred during the wintertime.

<u>*Essential Fish Habitat*</u>

According to literature published by the NMFS, James Island lies within the EFH area for summer flounder *(Paralichthys dentatus)*, windowpane flounder *(Scopthalmus aquosus)*, bluefish *(Pomatomus saltatrix)*, cobia *(Rachycentron canadum)*, red drum *(Sciaenops ocellatus)*, king mackerel *(Scomberomorus cavalla)*, and Spanish mackerel (*Scomeromorus* *maculatus)* (Section 4.1). The Chesapeake Bay is EFH only to juvenile and adult life stages of summer flounder, windowpane flounder, and bluefish. Cobia, king mackerel, and Spanish mackerel are highly migratory species, and the Chesapeake Bay is considered EFH to all of their life stages, but they usually occur as juveniles or adults in warmer, high salinity seasons.

Construction of the beneficial use project should not create impacts to spawning, egg, or larval habitat of the bluefish, because spawning and larval development occurs in the ocean, not in the Chesapeake Bay. Adult and juvenile bluefish generally migrate into the Bay between April and October. Bluefish adults and juveniles are highly migratory, and any present in the vicinity of the concept areas should have the ability to avoid unfavorable conditions caused by construction. Habitat within the proposed concept area does not appear to be unique relative to this species. However, once construction is complete there is a possibility that a few individuals may become trapped within the diked habitat restoration area.

Adult and juvenile summer flounder overwinter in the Ocean and only enter the Bay in the warmer months. Both life stages prefer warm shallow waters, and juveniles use salt marsh creeks, SAV beds, and other shallow shoreline habitats as nursery areas. Habitat within the proposed concept area does not appear to be unique relative to this species.

All life stages of windowpane flounder are reported to use estuaries from Delaware Bay, northward, and adults and juveniles are reported to enter the Chesapeake Bay during warmer seasons. Windowpane flounder are typically found along the bottom in sandy or fine substrates. Habitat within the proposed concept area does not appear to be unique relative to this species.

Spanish mackerel, cobia, and king mackerel are all highly migratory fish that prefer saline, warm waters. They can be found around sandy shoals of capes and offshore bars, and rocky or other high profile bottoms. As these species prefer saline waters, they rarely enter the mesohaline waters of the Chesapeake Bay where James Island is located; therefore, the construction within the proposed concept areas is not likely to adversely effect these species.

Like Spanish mackerel, cobia, and king mackerel, red drum also prefers saline waters. Juveniles reportedly prefer salinities of 20-40 ppt and are generally found throughout the southern, high salinity reaches of the Chesapeake Bay. Once they reach adulthood, red drums are generally found in deep water portions of estuary and river mouths. James Island is located in the mesohaline (8-15 ppt) portion of the Chesapeake Bay, and red drum tend to congregate in the southern portion of the Bay; therefore construction of the proposed habitat restoration area is not expected to adversely effect this species.

Of the seven EFH species identified, only three are expected in mesohaline portions of the Chesapeake Bay during the warmer months: summer flounder, windowpane flounder, and bluefish. Summer flounder and bluefish both support modest commercial fisheries in the Bay and Little Choptank River (Tables 6.4 and 6.5). Habitat within the proposed concept area does not appear to be unique relative to these species. Although it is believed there will be no negative impacts to the identified EFH species; consultations with NMFS may be required during proceeding studies.

6.2.3 Commercial Fishery

Any commercial harvesting, such as crabbing, that currently takes place within the proposed habitat restoration area footprint, alignments ranging from 978-2200 acres, will be displaced by construction. No fixed fishing gear was found within the area of the proposed footprint during the site visit. It appears that commercial fin fishing would likely be the least affected fishery. Construction of the habitat restoration area is not expected to greatly affect the menhaden fishery as it is distributed throughout the Bay.

Impacts to the soft shell clam fishery should be minimal, as the reportedly degraded state of the benthic community around James Island most likely limits any commercial clamming within the concept area. Crabbing occurs within the five proposed concept areas off of the northern and southern ends of the island and would no longer be able to occur there. No state recognized or historical oyster beds are within the concept areas. The boundaries of three recorded NOBs are located within 5000 ft (1524 m) of James Island. Care should be taken for portions closest to the dike construction to minimize or avoid temporary affects during construction of the dike enclosure. Further consultation with DNR would be needed regarding the proximity of construction to NOBs and the displacement of active crabbing sites. Time of year restrictions on construction activities may be expected to minimize impacts to the nearby oyster bars during construction.

Completed construction of the habitat restoration area should improve water quality in the area by reducing erosion and the resulting suspended solids, which may help sustain or improve the oyster fisheries in the area, and promote a revived clam fishery.

6.2.4 Recreational Resources

Some fishing and boating is likely to occur within the concept areas and would be permanently displaced by the proposed concepts, alignments ranging from 978-2200 acres. However, it is likely that the shallow depths preclude use by many sailing vessels, so the action would predominantly affect motorboats. It is expected that fishing will resume in the waters around the site once construction is completed and fish species begin to utilize the shoreline structure of the beneficial use project. Seasonal hunting occurs on James Island, and some of these activities may be affected by the island's proximity to the manned beneficial use area.

6.2.5 Historic Resources

James Island was residential and agricultural during the 19th and early 20th centuries. Some glass, brick, and pottery shards were found on the beach during the June 2001 site investigation. The MHT records archeological sites along the eastern shore of the island, but no archeological sites are reported to be within the concept areas. If unknown archeological sites are within the concept areas, construction of a habitat restoration area will prevent future access to any artifacts that may be within the project area. However, the proposed project will protect the remnant islands and any existing artifacts within them from future erosion. Formal consultations with the MHT would be appropriate if feasibility investigations of this site are conducted.

6.2.6 Other

Homeowners along the northern shore of Taylors Island and recreational boaters may experience some viewshed and sound disturbances during construction, but these should be short term and minimized by distance as well as the current James Island landmass. Construction of the habitat restoration area may be visible from three of the four historic properties identified on Taylors Island. Although visibility will be distant from the historic properties and consistent with historic viewsheds, further consultation with MHT may be needed. There may be some noise disturbances to recreational boaters during construction and filling activities; however, no noise disturbances are expected elsewhere because fixed receptors (e.g. homes) are sufficiently far from the potential construction areas. There is no indication of a CERCLA liability connected with the proposed concept areas.

Impact to navigation is expected to be minimal because local knowledge is needed to navigate the shallow waters immediately adjacent to the island. Barge and tug traffic transporting materials to the concept area may interact with commercial and pleasure boats, but this would cease once placement is complete. The concept area is defined as a Chesapeake Bay critical area, but the issue should be mitigated due to the beneficial use component of the project. Consultation with Dorchester County would be appropriate if development of this site is undertaken.

Potential contamination of groundwater is always an issue for this type of project. The geological characteristics of the bottom in this area militate against a connection between the project and aquifers. Furthermore, only clean material from east of the North Point-Rock Point line will be used for the project and no contamination is expected.

7.0 SUMMARY AND CONCLUSIONS

James Island is in the preliminary stages of evaluation as a beneficial use of dredged material project for restoration of island habitat. The study elements completed for this conceptual consolidated report included subsurface geological conditions, coastal engineering conditions, site placement and engineering conditions, and environmental conditions. The analysis for each of these studies was conducted at a conceptual level; therefore, the results should be considered preliminary. Reconnaissance or higher level studies for each element would be needed prior to implementing the proposed project.

The suggestion to consider James Island as a beneficial use project for island habitat restoration came from the Dorchester County Resource Preservation and Development Corporation, a non-profit citizen organization. The James Island owners willingly support the proposed restoration using dredged material.

- There are five alignment options, two upland dike height scenarios, and two borrow source options, totaling 20 option combinations for the James Island habitat restoration area.

- Some alignments are potentially close enough to Taylors Island to be connected by a bridge a bridge or causeway, however further studies would be needed to evaluate this consideration. The range of total preliminary costs for construction is about $372 million to $1.2 billion.

- The total costs per cubic yard of site capacity currently range from $14.78/cy to $15.91/cy. The limited geotechnical information currently available may be the most likely source of additional cost. These cost estimates will be refined as the study proceeds and as additional data is collected.

- The MGS preliminary literature search indicates that the extent of the sand in the Kent Island Formation is unknown and may not provide a suitable source of sand for dike construction.

- Studies indicate that prevalent wind and wave directions are from the north, northeast, south, and northwest.

- The design parameter data indicate that the dike should have an outer slope of 3 horizontal to 1 vertical (3:1) and an inner slope of 5:1. The required crest elevations were determined highest for the northwestern dikes, ranging from 11.8 to 16.4 feet. The maximum size of armor stone for a dike with a 3:1 slope for a 5-year event was 1.3 tons and for a 100-year event was calculated to be 5.6 tons for dike sections exposed to the northwest range.

- The estimated schedule for construction is about 1 – 3 years, depending on the borrow method used. Borrow method 4 is considered the most feasible method available for this project.

- The depths at the site are relatively shallow and hypoxia and/or anoxia are not expected as in deeper areas of the Bay in warmer months. Aerial photographs show that localized turbidity plumes currently extend outward from James Island, possibly affecting benthic habitat. Dissolved oxygen and salinity, were found to be within reasonable parameters.

- Any effects from discharging effluent from dredged material placement into background waters would be localized and likely to consist of small increases in suspended solids concentrations, fluctuations in pH, and elevated levels of nutrients. These effects would be monitored and coordinated with the appropriate regulatory agencies.

- Contamination to the sediments is not expected as a result of the restoration project and the project will result in renewed habitat and protection from erosion for James Island. It is not likely that different types or sizes of clean sediments will adversely affect the sediment quality.

- Aquatic species will be displaced from the concept areas (between 978-2200 acres), but will not be displaced in areas outside of the proposed footprint.

- Any benthic organisms within the footprint of the concept area (between 978-2200 acres) would be lost at the time of construction. B-IBI scores indicate that the benthic community around James Island is degraded. By protecting James Island from further erosion, the restoration project may improve conditions conducive to a healthy benthic community.

- No SAV beds have been reported within the concept area. Construction of the habitat restoration area on the western side of James Island may increase turbidity during construction; but once construction is complete the restoration project should improve overall water quality by decreasing turbidity and promoting conditions for SAV growth in the area.

- The proposed restoration area alignments are not attached to the existing James Island remnants and therefore are not expected to adversely impact terrestrial vegetation on James Island. Construction of the habitat restoration area on the western side of James Island should protect terrestrial vegetation from continued loss due to erosion.

- The proposed habitat restoration area is not expected to adversely affect wetlands on James Island, as the concept area is not attached to its shoreline. Construction of the habitat restoration area on the western side of James Island should protect wetland vegetation from being lost due to erosion.

- The habitat restoration area is expected to provide nesting habitat for birds and wildlife habitat. Noise and activity from the construction may cause animals to avoid the areas of James Island closest to the construction, but these effects should end after construction is completed.

- There have been no reported SNS or Atlantic sturgeon catches in the vicinity of the concept area.

- Any commercial harvesting, such as crabbing, that currently takes place within the proposed habitat restoration area footprint, between 978-2200 acres, will be displaced by construction. No known NOBs are located within the concept area. Completed construction of the habitat restoration area is expected to improve water quality in the area by reducing erosion and the resulting suspended solids. This may help sustain or improve the oyster fisheries in the area, and promote a revived clam fishery. Time of year restrictions on construction activities would be expected to minimize impacts to the nearby oyster bars during construction

- Of the seven EFH species identified, three are expected in mesohaline portions of the Chesapeake Bay during the warmer months: summer flounder, windowpane flounder, and bluefish. Negative impacts are not expected to the identified EFH species.

- The habitat restoration area would permanently displace the fishing and boating that occurs within the concept areas between 978-2200 acres. It is likely that the shallow depths preclude use by many sailing vessels, so the action would predominantly affect shallow draft motorboats. Additionally some recreational activities such as hunting on the island may be limited due to the island's proximity to the manned habitat restoration area.

- No archeological sites are reported to be within the concept areas. Construction of the habitat restoration area may be visible at a distance from three of the four historic properties identified on Taylors Island. Formal consultations with the MHT may be required if feasibility investigations of this site were conducted.

- The proposed project is not expected to affect groundwater as the subsurface geology of the area would prevent water percolating through the proposed project and into public aquifers; furthermore, only clean sediments will be placed in the beneficial use project.

- Recreational boaters and residences on the northern shore of Taylors Island and eastern shore nearest James Island may experience some minimal, short-term viewshed disturbance during construction of the project, but the landmass and trees of the James Island remnants should block most of the construction activities from the view of shoreline properties. There may be some noise disturbances to boaters during construction and filling activities but not to residents, due to distance.

- Preliminary evaluations of James Island and the proposed concept areas have indicated that no hazardous, toxic or radioactive substances exist within the project area. There is no indication of a CERCLA or UXO liability connected with the proposed concept areas.

- The proposed concept areas are between 978-2200 acres, are also considered to be within the state defined Critical Areas, because they are located within the tidal waters and tributaries of the Chesapeake Bay. This issue should be mitigated due to the beneficial use component of the project.

- Impact to navigation is expected to be minimal because so few boats can utilize the shallow waters immediately adjacent to the island. Barge and tug traffic transporting materials to the concept area may interact with pleasure boats, but would cease once placement is complete. Use of the site for the placement of dredged materials would support maintenance of regional navigation projects and help prevent further shoaling around the island.

This James Island restoration project is anticipated to have positive environmental attributes. The project is expected to have an overall positive effect on aquatic resources in the area by stabilizing the eroding banks of James Island, and could potentially protect other nearby shorelines of Dorchester County. Once construction is complete water quality in the area should improve. It is also expected to provide remote nesting habitat for birds.

8.0 FUTURE STUDY NEEDS

Data gaps have been identified in several areas. If this site moves forward in the study process, the following studies are suggested:

- Site-specific sediment quality sampling.
- Bathymetric and water quality studies.
- Continued monitoring of SAV in the area.

- Benthic investigations.
- Continued coordination on SNS and other RTE species such as the bald eagle; obtaining a biological opinion for the site, if necessary.
- EFH coordination with NMFS.
- Evaluate commercial harvesting near the site.
- Confirm locations and depths of wells and perform a more in-depth analysis of groundwater in the area.
- Coordination with the Maryland Historic Trust regarding archaeological resources in and around the concept area.
- Coordination with the Maryland Historic Trust regarding viewshed impacts on the historical properties identified on Taylors Island.
- Critical Areas coordination with Dorchester County regarding critical areas issues.
- Assessment of recreational boating and fishing activity in the vicinity.
- Conduct in-depth geological field investigations to identify potential and size of sand borrow available at the site.
- Conduct in-depth coastal engineering investigations.
- Hydrodynamic investigations.
- Reconnaissance level coastal engineering and dredging and site engineering studies.
- A feasibility study and engineering design would be needed to implement the proposed project.
- Study the potential for connecting the proposed habitat restoration project to Taylors Island.
- Conduct geotechnical field studies.
- In depth examination of sub-bottom acoustic data and side scan sonar data collected in 2000.

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Appendix A: Site Visit Report & Photographs

James Island Site Visit Summary
June 26, 2001

On Tuesday, June 26, 2001 at approximately 11:45 AM, Maryland Environmental Service (MES) personnel arrived in the waters surrounding James Island. The weather was clear and sunny (80° Fahrenheit). James Island is composed of three main island remnants; labeled as the northern, center and southern remnants for purposes of this discussion. MES personnel initially approached the island by boat from the north and headed south along the western side of the island remnants. The MES vessel circled the island remnants in a counter-clockwise direction. MES personnel took photos of James Island which are attached.

Several crab pots were visible on the north end of the remnant islands. Along the western side of the northern remnant a significant number of tree snags were visible above the waterline. Sediment banks of 5 ft or more were noticeable along the western shoreline of the northern remnant (Photo 1). An osprey (*Pandion haliaetus*) was observed in flight over the northern remnant. A larger bird species was also observed in flight. However, due to the distance, the species was unknown.

A sandy spit connects the northern (Photo 2) and central island remnants (Photo 3). Eroded sediment banks were evident on the western shore of the central remnant. Wooded areas containing pines, possibly loblolly (*Pinacea Pinus taeda*), and spruces were visible. Some deciduous tree species were present as well. On the southwestern tip of the central remnant (Photo 4), a great blue heron (*Ardea herodias*) and common terns were observed. A duck blind was observed on the southern tip of the central remnant.

The northern tip of the southern remnant had eroded away from the ma in part of the remnant (Photo 5), forming a small island. Along the eastern and western side of the southern island remnant (Photos 6, 7), common terns (*Sterna hirundo*), osprey, and bald eagles (*Haliaeetus leucocephalus*) were observed in flight. It was not apparent if the eagles had a nest on the island. The eagles were also observed in flight on the southwestern side of the island. A nest with osprey perched nearby was observed on the southern end of the southern remnant. The nest was located in a dead tree at the water's edge (Photo 8). Eroded sediment banks of 5 to 8+ ft were visible (Photo 9). Crab pot lines were observed south of the southernmost remnant in about 5 ft of water. South of the green buoy (shoal marker), cownose rays (*Rhinoptera bonasus*) were observed. Greenheaded horseflies (*Tabanidae*) were plentiful in this area.

Along the eastern side of the southern remnant, sandy yellow soil was observed on the eroding sediment bank (Photo 10). A marsh area was also observed on the southern tip, most likely containing *Spartina patens* (Photo 11). Two bald eagles were observed in flight along the eastern shore of the southern remnant. One of the eagles flew off towards Taylor's Island; the other flew into the wooded area on the southern remnant. There were no visible signs of eagles nesting on the island. Another bird of prey, possibly a red tailed hawk (*Buteo jamaicensis*), was observed in flight as well. Ospreys were also observed in flight along the southeast end of the southern remnant. Two cove areas bordered by marshes were evident on the eastern side of the southern remnant; one marsh area contained a duck blind with a sign and registration numbers posted (Photo 12).

An osprey nest was observed on the eastern side of the central remnant (Photo 13), but appeared to be in poor condition. To the north, in a slightly grassy area, another duck blind was observed.

The boat was anchored on the eastern side of the island, in a cove formed by the sandy spit connecting the central and northern remnants (Photo 14). In the cove, small beds of submerged aquatic vegetation (SAV) were observed. Eelgrass (*Zostera marina*) was observed in some of these beds. In the cove both sea nettles (*Chrysaora quinquecirrha*) and moon jellyfish (*Aurelia aurita*) were visible. Cownose rays and schools of small fish (Photo 15) were also observed.

While the boat was anchored, the sandy beach area between the central and northern remnant was explored. Deer tracks (Photo 16) and raccoon (*Procyon lotor*) tracks were present on the beach. Blue crab (*Callinectes sapidus*) shells (Photo 17), and a dead diamondback terrapin (*Malaclemys terrapin*) (Photo 18), razor clam (*Tagelus plebius*) and oyster (*Crassostrea virginica*) shells were also observed. Two areas on the beach with depressions and shell debris were observed, and believed to be former turtle nests (Photo 19); species unknown. Along the beach, broken glass (green and blue in color), brick (Photo 17), and pottery debris were found. Two brackish, tidal ponds were located on the northeastern and southwestern ends of the beach, respectively. The pond on the northeastern end had smooth cordgrass (*Spartina alterniflora)* (Photo 20, 21). The pond on the southwestern end contained small fish, tadpoles, and SAV (Photo 22). The soils in the pond appeared to be hydric (Photo 23). Sediments just off of the western side on the beach area consisted of a layer of sand (approximately 6 inches deep) covering a dark layer of clay (Photo 24). Also on the western side of the island, peat was accumulating, assumed to be from eroding phragmites (*Phragmites australis*) and other organic matter decaying and exposed from beach erosion (Photo 25). The surface sediments on the eastern side of the island were sandy approximately 10 feet from the shoreline, and then became silty/clayey and dark in color further out from the shoreline. Spike rush (*Eleocharis quadrangulata*) and salt meadow cordgrass (*Spartina patens),* and phragmites were found growing along the beach (Photo 26). In addition, several stands of phragmites were noted growing in the wetland areas. These stands were not large and covered less than 10% of the wetland area.

Once the boat left the sandy beach area, it headed north, along the eastern side of the northern remnant (Photos 27, 28). There were sediment banks along the eastern side, approximately 5 to +10 ft in elevation. Multiple snags were evident and plentiful along the entire northeastern shore (Photos 29, 30, 31, 32). Significant erosion was visible on the eastern shore of the northern remnant (Photos 33, 34). Stands of loblolly pines were present along the northern remnant. Ospreys were observed in flight. An area, clear of trees was observed on the northeastern shore of the northern remnant. This clearing was bermed and contained a meadow of emergent plants in standing water, thought to be freshwater (Photos 35, 36, 37). This pond was probably manmade due to the presence of a berm on three of its sides (Photo 38). A berm on the eastern side had probably eroded away, which prevented the pond from collecting water. A sample of vegetation from the pond area included tall beak rush (*Rhynchohospora macrostachya*).

Photo 1. James Island. Eroded western shoreline of the Northern remnant. Note tree snags along the shoreline.

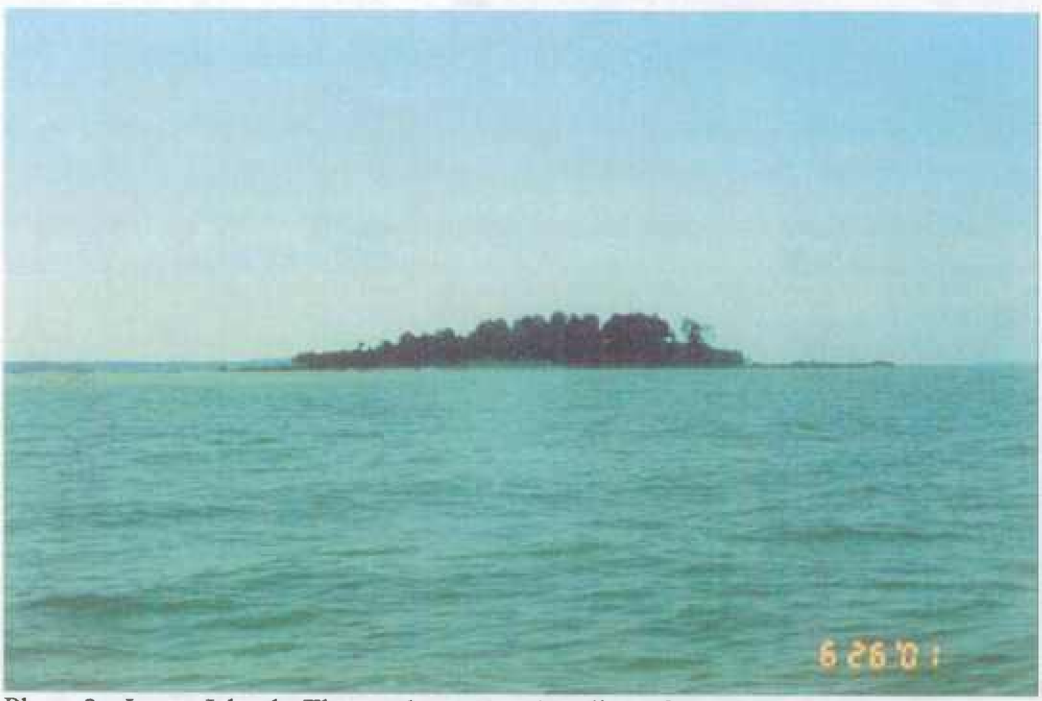


Photo 2. James Island. The northwestern shoreline of the Central remnant

Photo 3. James Island. Northwest shore of the Central remnant and the tip of the Southern remnant (far right).

Photo 4. James Island. Wetland area along the western shore of the Central remnant. A great blue heron and common terns were sighted in this vicinity.

Photo 5. James Island. Northern tip of the Southern remnant; note the small wetland island and probable wetlands on the tip of the remnant.

Photo 6. James Island. Marsh area on the tip of the Southern remnant's eastern shoreline.

Photo 7. James Island. Southern tip of the Southern remnant; a bald eagle was sighted in this area.

Photo 8. James Island. Osprey nest (assumed) on southern tip of the Southern remnant. Ospreys were seen perched nearby. A bald eagle and ospreys were sighted in this area.

Photo 9. James Island. Erosion along the shoreline of the Southern remnant.

Photo 10. James Island. Marsh area and eroded bank along the southern shoreline of the Southern remnant. The exposed soil is yellow/orange in color.

Photo 11. James Island. Marsh area along the eastern shoreline of the Southern remnant.

Photo 12. James Island. A duck blind in the marshy areas along the eastern shore of the Southern remnant.

Photo 13. James Island. Nest observed along western shoreline of the Central remnant.

Photo 14. James Island. Central spit and a portion of the wooded and marsh areas on the eastern shoreline of the Northern remnant. The central spit connects the Northern and Central remnants.

Photo 15. James Island. Disturbance of surface water caused by a school of small fish observed swimming in the waters off of the eastern side of the central spit.

Photo 16. James Island. Deer tracks on the eastern beach of the spit between the Central and Northern remnants.

Photo 17. James Island. Blue Crab shell and brick debris found on eastern beach of sand spit.

Photo 18. James Island. Dead Diamondback Terrapin on the eastern shoreline of the sand spit.

Photo 19. James Island. Turtle egg shells around the remnants of a nest on the eastern side of the sand spit.

Photo 20. On James Island, smooth cordgrass *(Spartina alterniflora)* growing in the pond on the northeastern end of spit.

Photo 21. James Island. Smooth cordgrass growing in and around the pond on the northeastern end of spit.

Photo 22. James Island. Pond on the southwest end of spit which contained tadpoles, minnows, and SAV.

Photo 23. James Island. Hydric sediments around the pond along the southwest end of the sand spit.

Photo 24. James Island. Dark sediments present under thin sand layer along the western shoreline of the spit.

Photo 25. James Island. Decomposing roots and organic matter on the western shoreline of the spit.

Photo 26. James Island. Marsh running along the eastern shoreline of the middle portion of the spit. *Spartina patens* is growing on the edge of the marsh; *Phragmites australis* is growing in the central portion of the marsh.

Photo 27. James Island. The eastern side of the Central and Northern remnants.

Photo 28. James Island. Eastern shoreline of the Northern remnant.

Photo 29. James Island. The eroded eastern shoreline of the Northern remnant.

Photo 30. James Island. Snags along the eroded eastern shoreline of the Northern remnant. The pictured shoreline is adjacent to a clearing visible in the center of the photo.

Photo 31. James Island. Eroded banks and snags along the eastern shoreline of the Northern remnant.

Photo 32. James Island. Eroded banks and snags along the northeast shore of the Northern remnant.

Photo 33. James Island. Visible erosion on eastern banks of the Northern remnant.

Photo 34. James Island. Visible erosion on eastern banks of the Northern remnant.

Photo 35. James Island. Wet meadow in forested upland area of the Northern remnant.

Photo 36. James Island. Meadow on the northern remnant. Tall beak-rush is visible in the foreground, and young loblolly pines are visible behind the sedge.

Photo 37. James Island. The meadow from the eastern end of the Northern remnant.

Photo 38. James Island. Berm located on north side of the meadow in the Northern remnant. The meadow had berms along the northern, western, and southern sides.

Appendix B: Subsurface Geological Investigations

PRELIMINARY INVESTIGATION OF THE SUBSURFACE GEOLOGY IN THE VICINITY OF JAMES ISLAND, DORCHESTER COUNTY

Jeffrey Halka
Maryland Geological Survey
March 2000

INTRODUCTION

James Island, located on the southwest side of the Little Choptank River, is a rapidly eroding island that has lost much of its land area in the recent past. The suggestion has been put forth that this island could be a suitable location for the placement of dredged sediment to restore its historical footprint, in much the same manner as Poplar Island, located in Talbot County. A critical factor in an island reconstruction project utilizing dredged sediment is to identify a suitable source of sand for construction of the containment dikes. The Maryland Geological Survey, Coastal and Estuarine Geology Program undertook a preliminary assessment of the local geology based on data that was readily available in the Survey offices. Data available included acoustic sub-bottom profiling information combined with county water resources reports and geologic maps. This assessment should assist in summarizing the regional geology and provide a basis for determining the need for more detailed subsurface investigations should the project move forward.

BACKGROUND INFORMATION

The initial data analyzed in this assessment was an east-west oriented sub-bottom profile collected along a trackline located 0.5 kilometers to the north of the island in the summer of 1987. The acoustic data were collected using two sub-bottom profiling devices, 1) a 5.0 kHz Datasonics transducer based system; and 2) an ORE Geopulse operating at 280 joules with the return signals filtered between 300 and 3,000 Hz. Both systems were triggered every 0.5 seconds. Maximum sub-bottom penetration was achieved with the higher energy, lower frequency Geopulse system, which returned information from roughly the upper 100 meters of the sediment section (sediment speed-of-sound assumed to be 1500 m/sec). The higher frequency Datasonics system permitted greater resolution of sub-bottom features but had a maximum penetration less than one-half of the Geopulse system.

Results from the Datasonics transducer system identified a strong, laterally persistent, shallow reflector located approximately 2-3 m below the present bay bottom. This reflector was present across the entire shallow water platform that extends to the north of James Island. Other than some small undulations with less than 0.5 m of relief, this reflector is generally parallel to the present water surface across the area surveyed. Assuming an average water depth of 3 meters on the platform surrounding James Island, this reflector is located approximately 5-6 meters below present sea level.

Based on the regional Pleistocene history of the Chesapeake Bay (Colman and Halka, 1989; Colman et al., 1990) and local geologic mapping in Dorchester County (Owens and Denny, 1986) this reflector most likely represents an erosion surface that was formed during a period of lower sea level in the mid-Pleistocene, approximately 150,000 years ago. As sea level rose following that time, a previous generation of the Chesapeake Bay formed in the region. The rising sea generated wave cut erosion of the land surface and formed a roughly horizontal surface at the wave base, producing this shallow reflector. Continued sea level rise formed a broader and deeper proto-Chesapeake Bay, and sediments were deposited on top of that erosion surface. Those sediments, comprising the upper portion of the sediment column in the vicinity of James Island, as well as James Island itself, constitute the Kent Island Formation (Owens and Denny, 1986). This formation forms the surface materials for almost the entire southwestern two-thirds of Dorchester County. Due to deposition in an environment similar to the present Chesapeake Bay, the sediments comprising the Kent Island formation can be anticipated to be largely fine grained silts and clays with some intermixed sands. The slightly coarser sands may be present in thin lenses and pockets throughout the formation, but the sub-bottom data provided no evidence of this in the James Island area. Owens and Denny (1986) describe the Kent Island Formation as "Interbedded silt, clay, and sand, with abundant organic matter in places. Clayey and silty sediments underlie most of Dorchester County..." They also note that the base of the unit is commonly placed at a gravel bed that overlies a black clay of the Miocene age Chesapeake Group (undifferentiated).

In the deeper sub-surface, the returns from the Geopulse system displayed a laterally persistent reflector located approximately 63 m below the surface. This reflector exhibited a slight dip to the east. Correlation with well-log data in Dorchester County indicated that this reflector represents the surface of the Miocene age Piney Point Formation (Williams, 1979). The Piney Point Formation thins and pinches out to the west before reaching the land surface along the western shore of the Bay.

In the vicinity of James Island, the Calvert Formation directly overlies the Piney Point Formation (Mack et al., 1971). Thus, the intervening section of sediments, located between the 5-6 meter deep reflector that represents the base of the Kent Island Formation and this 63 m deep reflector are composed of the Miocene Age Calvert Formation (a sub-unit of the Chesapeake Group).

Williams (1979) describes the Calvert Formation as "Gray diatamaceous silts and clays containing lenses of gray sand and shell beds. Largely an aquiclude, but contains two or three aquifers which locally yield large amounts of water at Easton, Federalsburg, Hurlock and Vienna." In order to function as aquifers the sediments that provide water would be composed predominantly of relatively coarser sands. However, these sections are probably not laterally extensive because of their localized nature. It is likely that the immediate subsurface sediments near James Island are composed of the uppermost sections of the Calvert Formation, because outcrops of Miocene age along the Choptank River west of Cambridge, near Hambrooks Bar, are identified as belonging to the overlying Choptank Formation (Cleaves, et al., 1968).

The Calvert Formation in Maryland consists of alternating fossiliferous, shelly sand beds and finer grained diatomaceous silty clays that contain fewer fossils (Kidwell, 1982). The uppermost portion of the Calvert Formation is identified informally as the "Turritella-Pandora" interval by Kidwell (1982). It is this portion that is presumed to lie in the immediate subsurface below James Island. In the exposures along Calvert Cliffs in Calvert County the Turritella-Pandora interval is described as consisting of a coarsening upward sequence of interbedded sands, muddy sands, and clays. The lower Turitella facies is described as a "b ioturbated muddy very fine sand", and the upper Pandora facies as having clay layers interlaminated with sand (Kidwell, 1982, p. 69). Grain size analysis of selected samples from the Calvert Cliffs region show the mud content of this interval as ranging from a minimum of about 10% to over 60% (Kidwell, 1982, Figure 3-2). Although Kidwell (1982) states that the beds and intervals of the Calvert and overlying Choptank Formations are laterally persistent, it is not certain that these beds can be assumed to continue unbroken and with the same grain size characteristics across the entire Chesapeake Bay from the measured sections at Calvert Cliffs.

Some subsurface information in the vicinity of James Island was presented in the Masters Thesis of Jacobs (1980). He collected a series of shallow wash borings and vibracores in the vicinity of Slaughter Creek and Slaughter Creek Broads, located to the east of James Island. These borings generally returned mixed silts, clays and sands in the upper 2 to 4 meters of section and fine to medium sand below this layer to the limits of the borings (-5 to -10 meters). In the lowermost sections a few of the borings contained variable amounts of silts in addition to the fine sands. The upper 2-4 meters of these borings are interpreted to represent the predominantly fine grained sediments of the Kent Island Formation, with the underlying sediments the older Calvert Formation.

Colman and Halka (1989) interpreted extensive sub-bottom acoustic profiles, including the line examined for this report, and placed a mid-Pleistocene age channel of the Susquehanna River just to the east of James Island (their Figures 7 and 10). They informally named this channel the Exmore Paleochannel and placed its age at either approximately 250,000 or 450,000 years age. The Exmore channel was completely filled with sediments during a subsequent rise in sea level as an estuary formed in the area. These sediments are probably largely fine grained in nature with little sand sized materials due to their deposition in an estuarine environment. The acoustic records support this interpretation because internal reflectors tend to be faint, persistent, and conformable with the underlying shape of the eroded channel. The exact location of this channel to the east of the Island cannot be determined because no survey data was collected on the shallow platform immediately to the east. However, it is highly likely that sediments of the Calvert formation would be encountered at greater depths to the east of James Island than to the west of the island. Colman and Halka (1989) show the depth to Tertiary age sediments (their Figure 8) as less than 5 meters below the water surface to the west of the island and at depths in excess of 15 meters to the east.

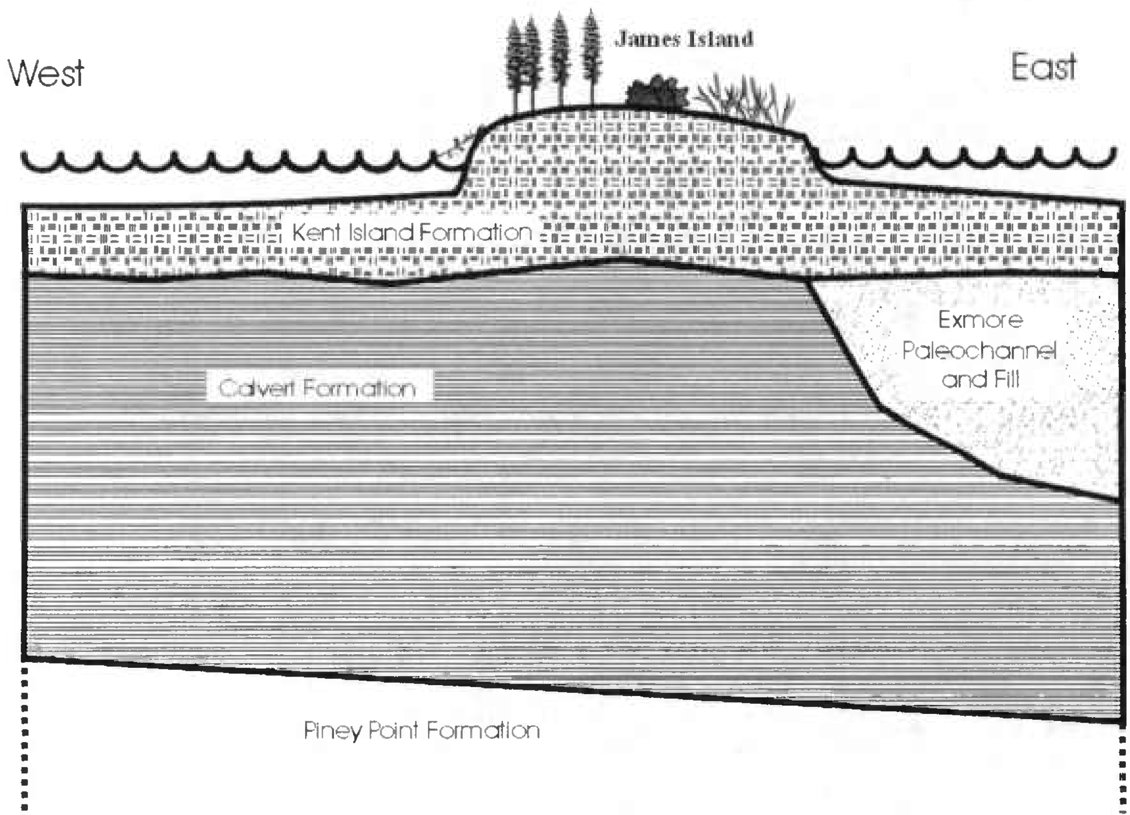
SUMMARY

Based on the reflectors observed in the acoustic sub-bottom profiles, the sediments below the platform surrounding James Island are interpreted to consist of three formations and a filled paleochannel. Over the entire area the upper 2-3 m of sediment represents the late Pleistocene Kent Island Formation, which generally overlies the Miocene age Calvert Formation. The Calvert extends to a depth of approximately 63 meters and overlies the Piney Point Formation. To the east of the Island a channel has been cut into the Calvert Formation by a paleo-Susquehanna River and was subsequently filled with sediments.

The Kent Island Formation, comprising the upper 2-3 meters of sediment is likely to consist predominantly of fine grained silts and clays that were deposited in the estuarine environment of a proto-Chesapeake Bay. While there may be some lenses and stringers of sandier sediments located within this formation they are likely to be limited in lateral extent and thickness. It is unlikely that the Kent Island would provide a suitable source of sand for dike construction. Furthermore, it would probably need to be removed to reach any underlying sediment. Similarly, the paleochannel located to the east of the Island is likely to be filled with fine grained sediments that were also deposited in an estuarine environment. In this area the fine grained sediments of Pleistocene age are likely extend to depths in excess of 15 m below the present water surface.

The textural characteristics of sediments that locally compose the underlying Calvert Formation are less certain. Owens and Denny (1986) state that the Kent Island Formation overlies a black clay of Miocene age under Dorchester County, but this general statement may or may not apply to the James Island area. Jacobs' thesis suggests that fine to medium grained sand underlies the Kent Island Formation in the vicinity of Slaughter Creek, and none of his figures indicate the presence of a gravel layer. It is not certain that sediments with these characteristics would extend from Slaughter Creek to the vicinity of James Island. Kidwell (1982) does note that the beds of the Calvert and Choptank formations are laterally extensive and that the Turritella-Pandora interval of the uppermost Calvert Formation has variable amounts of sand at least in the Calvert Cliffs area. It is uncertain that these sediment characteristics can be extended across the Bay. Given the laterally extensive nature of the sediments in this formation some borings in the vicinity of James Island may serve to identify whether or not suitable sand is present in the upper portions of the Calvert Formation. The majority of the borings should be located to the west of the island where the Calvert Formation is likely to be encountered at shallower depths. To the east of the island the Calvert was eroded to greater depths due to the downcutting of the Exmore paleochannel. Some borings in this area would serve to better define the location and depths of this paleochannel although it is likely to be filled with muddy sediments rather than sand.

The accompanying figure summarizes this interpretation of the local geology. The figure shows a cross section of the earth as if the viewer were located to the south of James Island looking to the north. The Chesapeake Bay is located to the left of the figure. Note that the figure is conceptual only. There is no scale shown because no actual data exists for subsurface sediments in the area immediately underlying the Island and surrounding vicinity. The base of the Kent Island formation is probably located 5-6 meters below the present water surface, and the interface between the Calvert and Piney Point Formations at a depth of over 60 meters. The location, slope and depth of the Exmore Paleochannel and fill are less certain in the area immediately to the east of James Island.



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Appendix C: Dredging Engineering and Cost Analyses

FINAL

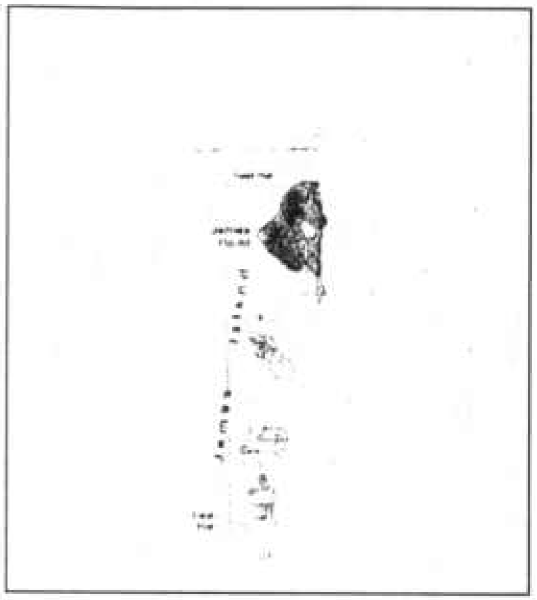
CONCEPTUAL STUDY

FOR

DREDGED MATERIAL PLACEMENT SITE CONSTRUCTION

AT

JAMES ISLAND



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GBA

Gahagan & Bryant Associates, Inc.

Baltimore, MD

October 25, 2001

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APPENDIX B TOTAL SITE USE COST ANALYSIS

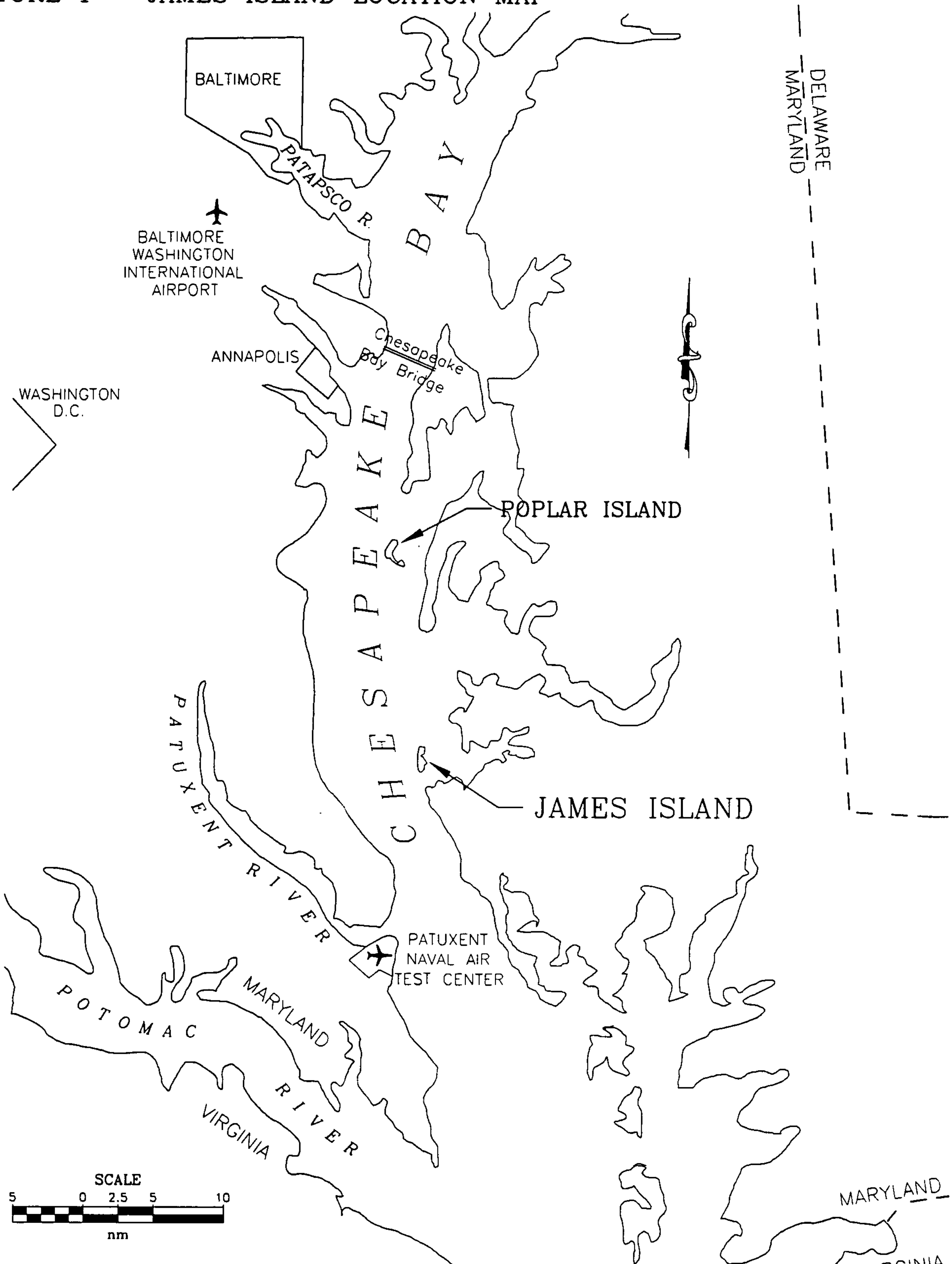
1.0 PROJECT BACKGROUND

The Maryland Environmental Service (MES), under sponsorship by the Maryland Port Administration (MPA), is examining the feasibility and suitability of certain sites for the placement of dredged material.

James Island (See Figure 1) is one site being studied for placement of dredged material for beneficial use. It is located approximately 15 nautical miles south of the Poplar Island Environmental Restoration Project. Gahagan & Bryant Associates, Inc. (GBA) was retained by MES to provide an initial dredging engineering assessment of site feasibility and construction costs.

GBA's scope is to evaluate the suitability of this site for construction of two dike height scenarios to enclose five island habitat restoration site configurations. Each dike alignment will be characterized by a 10 or 20 ft upland dike height. The ratio between upland and wetland areas will be 1 to 1. This report outlines the findings of this assessment.

FIGURE 1 – JAMES ISLAND LOCATION MAP



2.0 PROJECT OBJECTIVES

GBA's task is to provide a dredging engineering conceptual level assessment for the feasibility of constructing a habitat restoration site using dredged material at James Island. Specifically, GBA's tasks are comprised of the following:

Task 1 – Analyze four different sand borrow options and present cost information for two different sand borrow options, including excavation, transport and placement methods. There was no geotechnical field study for confirmation of foundation and sand borrow source. The four different options have been identified as follows: (1) mine sand from a land based quarry and transport it by truck (2) mine sand from a quarry and transport it by barge (3) dredge and transport off-site sand by hopper dredge to openwater placement site and place sand in dikes with hydraulic dredge (4) hydraulic dredge directly from on-site borrow. From the analysis performed in Section 4.0 Alternative Borrow Methods, borrow options 3 and 4 were the two most cost effective methods for this project.

Task 2 - Along with the staff of Moffatt & Nichol, Inc. (M & N) and MES, GBA will layout two scenarios for upland dike heights (10ft & 20ft) and for each scenario, layout five perimeter dike alignments, enclosing between 978 to 2,200 acres. Prepare plan drawings with overlays of shoreline data and other significant features.

Task 3 - Estimate neat quantities (quantity of material that fill the design template, not including material lost during construction) and construction quantities for the five alignments defined using Terramodel. Develop excavation, transport and placement costs for the two different sand borrow options and five perimeter dike alignments. Quantities and costs for unsuitable excavation and backfill will also be estimated.

Task 4 - Estimate neat quantities and construction quantities for all rock products based on dike cross sections developed by M & N Engineers. Obtain unit costs from M & N and estimates based on Poplar Island Phase I & Phase II for the following products:

1. Toe dike (quarry run and armor), slope stone (bedding, underlayer and armor), road stone, and geotextile.
2. Spillways, nursery planting

Summarize all line items in bid format and include item, quantity, unit cost and total costs (including mobilization and demobilization cost).

Task 5 - Estimate transport and placement cost of material dredged from Baltimore approach channels east of the North Point-Rock Point Line and proposed for placement at James Island. Estimate site finishing (habitat development) cost including: plan and design, habitat monitoring, implementation of channels and seeding, and operations and maintenance.

3.0 SITE AND DESIGN CHARACTERISTICS

3.1 Site Characteristics

James Island is a privately owned island that is located in Dorchester County, MD on the eastern shore of the Chesapeake Bay at the mouth of the Little Choptank River. Existing oyster bars are located adjacent to James Island, but not within any of the five proposed dike alignments.

GBA and MES designed five conceptual dike alignment options and two dike height options for each dike alignment for quantity takeoffs and cost estimating. Figures 2 thru 6 contain dike alignment and typical dike section layouts for the 5 alignments. Alignment No. 1 is a reduced area option with 20 and +/- 10 ft upland dike height scenarios (see Figure 2). The dike centerline area for Alignment No. 1 is 978 acres. The dike centerline area for Alignment No. 2 is 2,126 acres (see Figure 3). The dike centerline area for Alignment No. 3 is 1,586 acres (see Figure 4). The dike centerline area for alignment No. 4 is 2,200 acres (see Figure 5). The dike centerline area for alignment No. 5 is 2,072 acres (see Figure 6). Tables 1 thru 5 provide site characteristics for all dike alignments and dike heights scenarios including quantities for rock and hydraulic fill material. Some alignments are close enough to Taylor Island to be connected to a bridge. A further study would be needed to evaluate the bridge construction, clearance, costs and coastal effects.

3.2 Design Characteristics

James Island is located 15 miles south of Poplar Island and is similarly exposed to heavy wave action from the north, south and west. Preliminary quantity estimates are shown in Tables 1 thru 5. Typical dike sections similar to the dikes built at Poplar Island were used in design. The heavy armor is on the north, south and west dikes. The east dike is on the protected side of the island and is smaller with less rock armor and no toe dike. Typical dike sections are shown in Figure 7 for exterior dikes and Figure 8 for interior dikes.

Bathymetric and geotechnical information of the James Island area is limited at this time. Nautical charts show less than 2 feet of water to the south of James Island adjacent to Taylors Island. However, large fishing and pleasure boats use an unmarked channel between James and Taylors Island that has been deepened by boat traffic and natural processes.

Additional bathymetric, geotechnical and environmental data will be required for the feasibility. planning and design phases of this project, if undertaken.

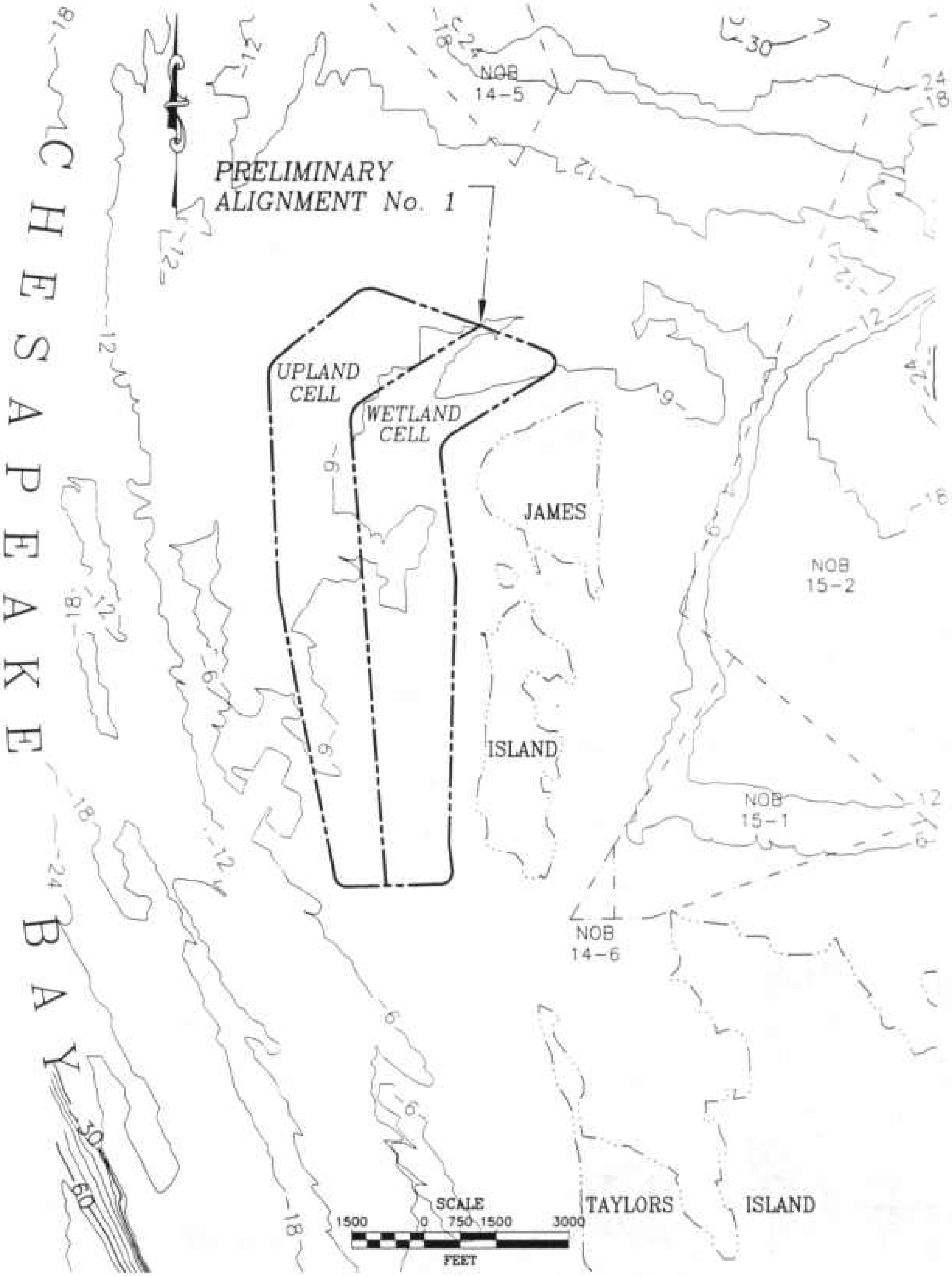


FIGURE 2. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 1

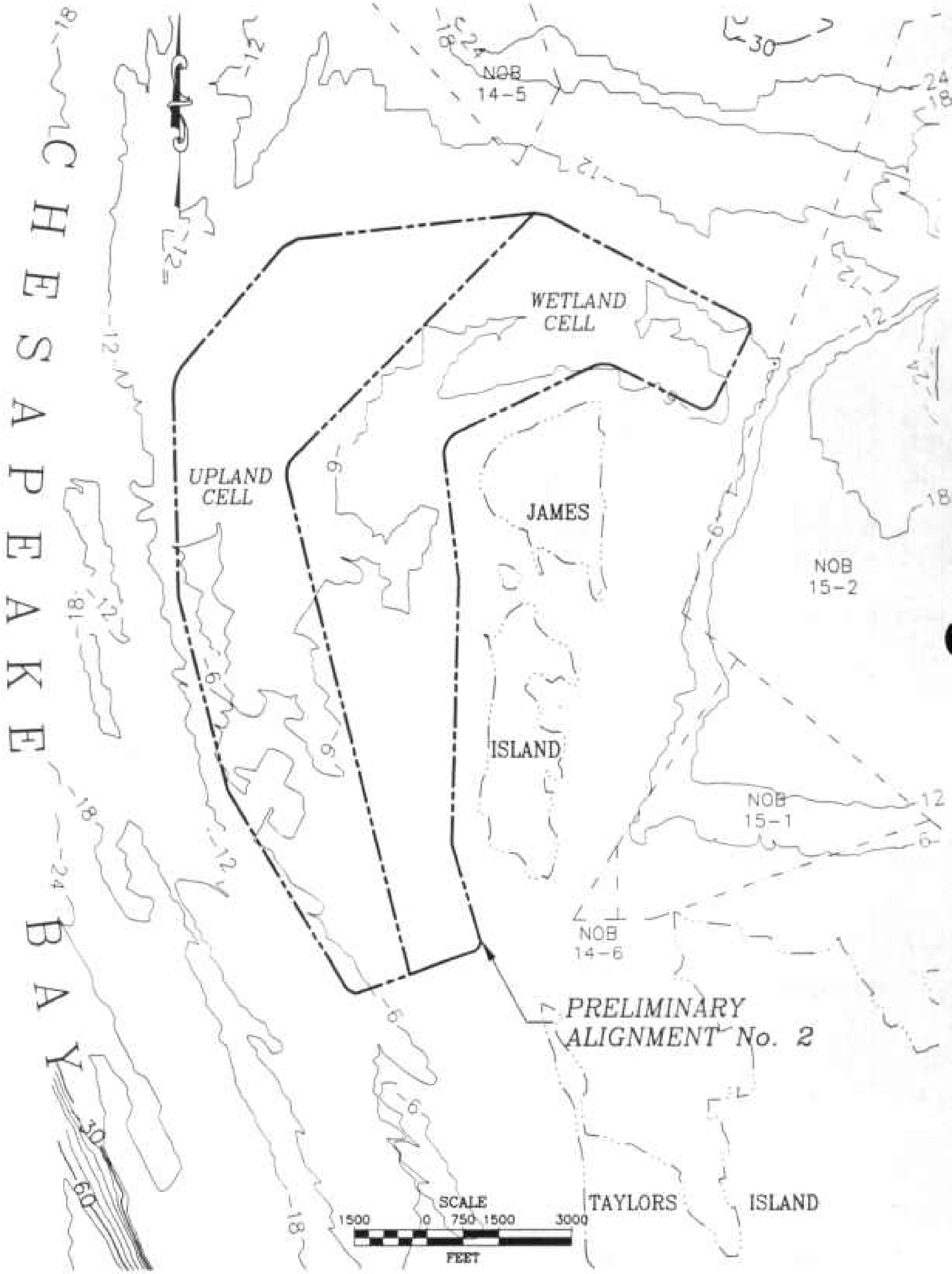


FIGURE 3. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 2

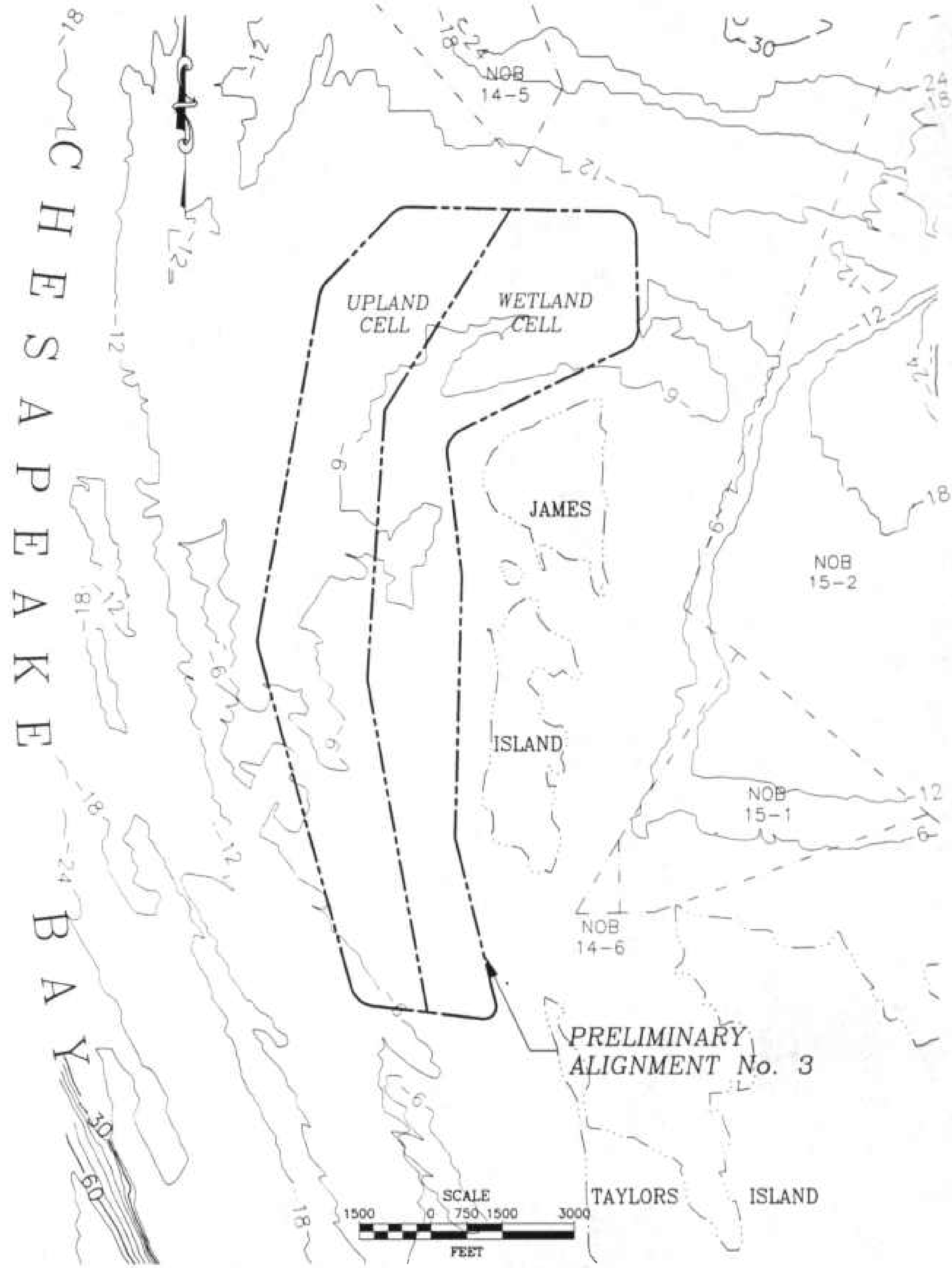


FIGURE 4. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 3

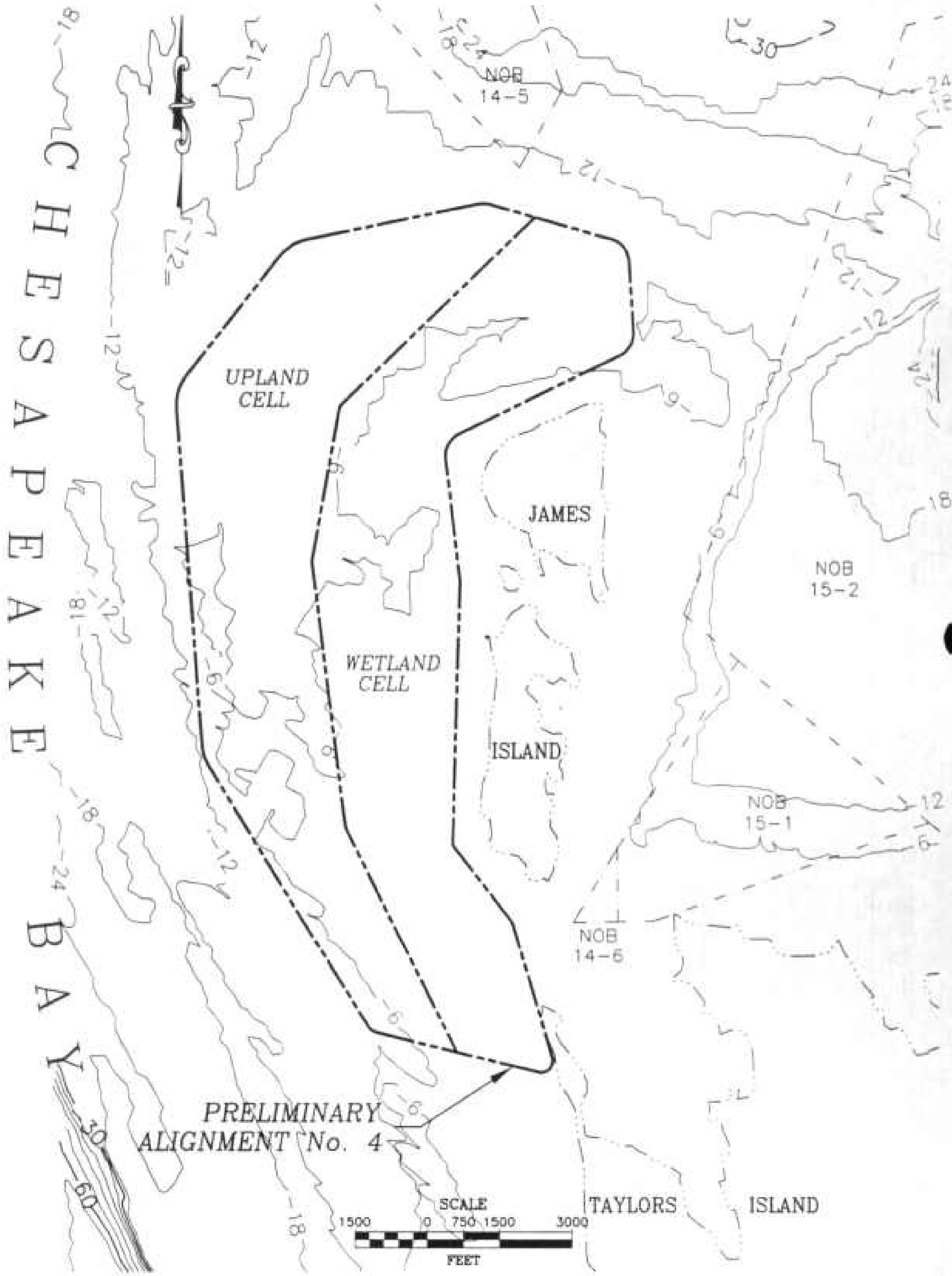


FIGURE 5. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 4

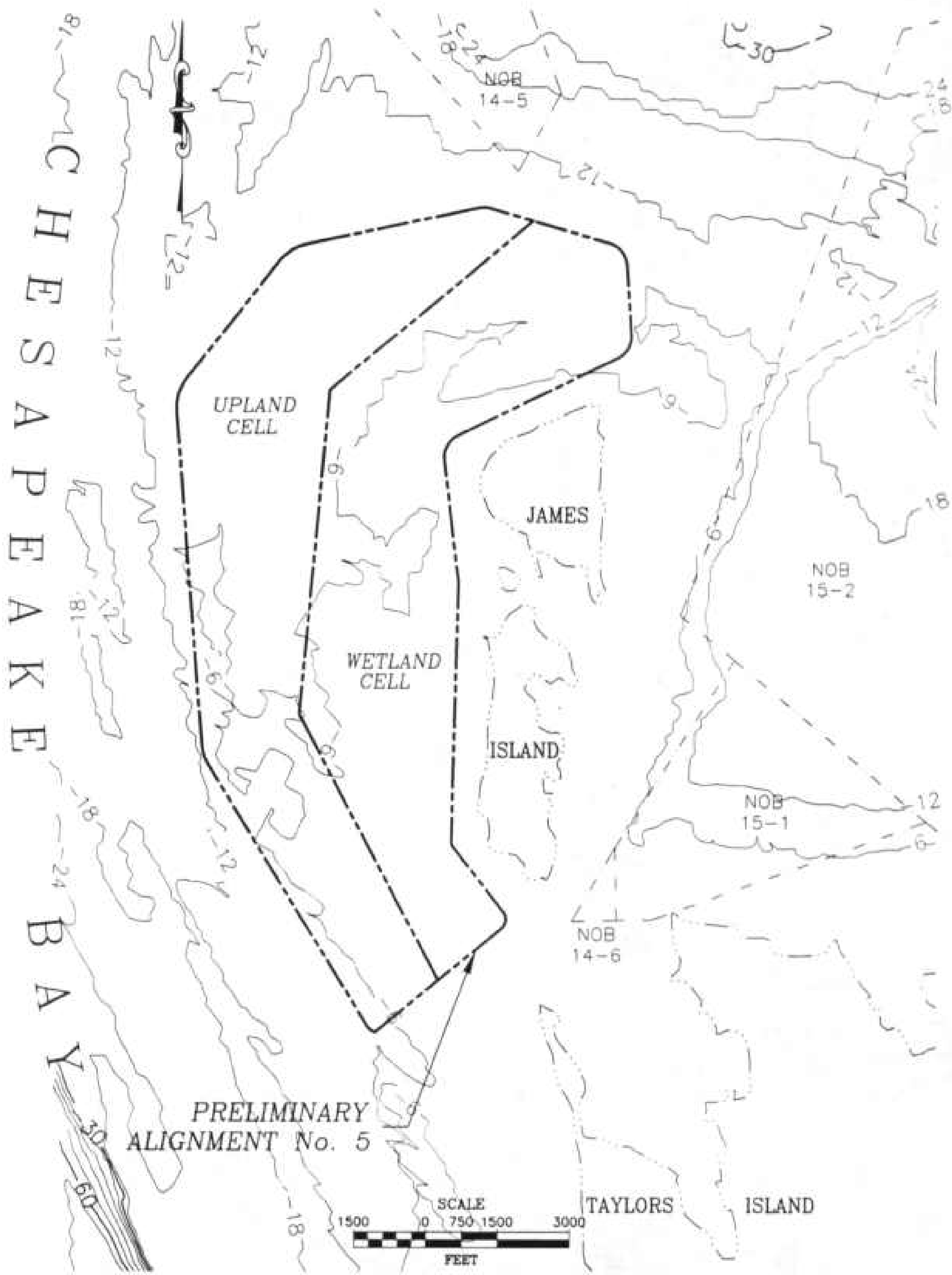


FIGURE 6. JAMES ISLAND PERIMETER DIKE ALIGNMENT No. 5

James Island Habitat Development

Table 1 - Preliminary Site Characteristics and Quantities   Alignment No. 1

SITE CHARACTERISTICS	Alignment No. 1 (10 ft)		Alignment No. 1 (20 ft)	
Upland Baseline Area -	489	Acres	489	Acres
Upland Baseline Perimeter -	30,026	LF	30,026	LF
Upland Site Volume below sea level -	6.3	MCY	6.3	MCY
Upland Site Volume above sea level -	6.3	MCY	14.2	MCY
Upland Site Volume -	12.6	MCY	20.5	MCY
Upland Site Capacity -	18.1	MCY	30.3	MCY
Wetland Baseline Area -	489	Acres	489	Acres
Wetland Baseline Perimeter -	28,212	LF	28,212	LF
Wetland Site Volume below sea level -	2.8	MCY	2.8	MCY
Wetland Site Volume above sea level -	1.2	MCY	1.2	MCY
Wetland Site Volume -	3.9	MCY	3.9	MCY
Wetland Site Capacity -	5.5	MCY	5.5	MCY
Total Baseline Area -	978	Acres	978	Acres
Total Baseline Perimeter -	32,102	LF	32,102	LF
Total Interior Dike -	13,068	LF	13,068	LF
Total Volume -	16.6	MCY	24.5	MCY
Total Site Capacity -	23.6	MCY	35.8	MCY

QUANTITIES	Alignment No. 1 (10 ft)			Alignment No. 1 (20 ft)		
Hydraulic Fill Material	LF	CY/LF	CY	LF	CY/LF	CY
Unsuitable Backfill -			250,000			250,000
Perimeter Dikes to +08 -	15,144	22.35	338,474	15,144	22.35	338,474
Perimeter Dikes to +10 -	16,958	38.48	652,539			
Perimeter Dikes to +20 -				16,958	89.44	1,516,711
Interior Dikes to +10 -	13,068	35.25	460,649			
Interior Dikes to +20 -				13,068	60.62	792,186
Total -	45,170		1,701,661	45,170		2,897,371
Perimeter Dike Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	20,085	5.5	110,470	20,085	5.5	110,470
Toe Armor -	20,085	7.0	140,598	20,085	7.0	140,598
Bedding Stone -	20,085	1.0	20,085	20,085	1.0	20,085
Underlayer Stone -	20,085	4.0	80,342	20,085	4.0	80,342
West Dike Armor -	20,085	10.0	200,855	20,085	10.0	200,855
East Dike Armor -	12,017	3.5	42,058	12,017	3.5	42,058
Miscellaneous	LF	SY/LF	SY	LF	SY/LF	SY
Road Stone -	45,170	3.0	135,510	45,170	3.0	135,510
Geotextile -	32,102	13	417,327	32,102	13	417,327

James Island Habitat Development

Table 2 - Preliminary Site Characteristics and Quantities   Alignment No. 2

	Alignment No. 2 (10 ft)			Alignment No. 2 (20 ft)		
SITE CHARACTERISTICS						
Upland Baseline Area -	1,063	Acres		1,063	Acres	
Upland Baseline Perimeter -	41,818	LF		41,818	LF	
Upland Site Volume below sea level -	13.7	MCY		13.7	MCY	
Upland Site Volume above sea level -	13.7	MCY		30.9	MCY	
Upland Site Volume -	27.4	MCY		44.6	MCY	
Upland Site Capacity -	39.4	MCY		65.8	MCY	
Wetland Baseline Area -	1,063	Acres		1,063	Acres	
Wetland Baseline Perimeter -	43,310	LF		43,310	LF	
Wetland Site Volume below sea level -	8.6	MCY		8.6	MCY	
Wetland Site Volume above sea level -	2.6	MCY		2.6	MCY	
Wetland Site Volume -	11.1	MCY		11.1	MCY	
Wetland Site Capacity -	15.4	MCY		15.4	MCY	
Total Baseline Area -	2,126	Acres		2,126	Acres	
Total Baseline Perimeter -	48,812	LF		48,812	LF	
Total Interior Dike -	18,158	LF		18,158	LF	
Total Volume -	38.6	MCY		55.7	MCY	
Total Site Capacity -	54.8	MCY		81.2	MCY	
QUANTITIES	Alignment No. 2 (10 ft)			Alignment No. 2 (20 ft)		
Hydraulic Fill Material	LF	CY/LF	CY	LF	CY/LF	CY
Unsuitable Backfill -			250,000			250,000
Perimeter Dikes to +08 -	25,152	22.35	562,142	25,152	22.35	562,142
Perimeter Dikes to +10 -	23,660	38.48	910,435			
Perimeter Dikes to +20 -				23,660	89.44	2,116,147
Interior Dikes to +10 -	18,158	35.25	640,082			
Interior Dikes to +20 -				18,158	60.62	1,100,759
Total -	**66,970**		2,362,659	**66,970**		4,029,048
Perimeter Dike Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	29,491	5.5	162,201	29,491	5.5	162,201
Toe Armor -	29,491	7.0	206,438	29,491	7.0	206,438
Bedding Stone -	29,491	1.0	29,491	29,491	1.0	29,491
Underlayer Stone -	29,491	4.0	117,965	29,491	4.0	117,965
West Dike Armor -	29,491	10.0	294,911	29,491	10.0	294,911
East Dike Armor -	19,321	3.5	67,622	19,321	3.5	67,622
Miscellaneous	LF	SY/LF	SY	LF	SY/LF	SY
Road Stone -	66,970	3.0	200,910	66,970	3.0	200,910
Geotextile -	48,812	13	634,552	48,812	13	634,552

James Island Habitat Development

Table 3 - Preliminary Site Characteristics and Quantities Alignment No. 3

SITE CHARACTERISTICS	Alignment No. 3 (10 ft)			Alignment No. 3 (20 ft)		
Upland Baseline Area -	793	Acres		793	Acres	
Upland Baseline Perimeter -	39,047	LF		39,047	LF	
Upland Site Volume below sea level -	9.0	MCY		9.0	MCY	
Upland Site Volume above sea level -	10.2	MCY		23.0	MCY	
Upland Site Volume -	19.2	MCY		32.0	MCY	
Upland Site Capacity -	27.7	MCY		47.4	MCY	
Wetland Baseline Area -	793	Acres		793	Acres	
Wetland Baseline Perimeter -	40,707	LF		40,707	LF	
Wetland Site Volume below sea level -	5.8	MCY		5.8	MCY	
Wetland Site Volume above sea level -	1.9	MCY		1.9	MCY	
Wetland Site Volume -	7.7	MCY		7.7	MCY	
Wetland Site Capacity -	10.6	MCY		10.6	MCY	
Total Baseline Area -	1,586	Acres		1,586	Acres	
Total Baseline Perimeter -	44,497	LF		44,497	LF	
Total Interior Dike -	17,628	LF		17,628	LF	
Total Volume -	26.9	MCY		39.7	MCY	
Total Site Capacity -	38.3	MCY		58.0	MCY	

QUANTITIES	Alignment No. 3 (10 ft)			Alignment No. 3 (20 ft)		
Hydraulic Fill Material	LF	CY/LF	CY	LF	CY/LF	CY
Unsuitable Backfill -			250,000			250,000
Perimeter Dikes to +08 -	23,079	22.35	515,812	23,079	22.35	515,812
Perimeter Dikes to +10 -	21,418	38.48	824,181			
Perimeter Dikes to +20 -				21,418	89.44	1,915,664
Interior Dikes to +10 -	17,628	35.25	621,399			
Interior Dikes to +20 -				17,628	60.62	1,068,630
Total -	**62,126**		2,211,393	**62,126**		3,750,107
Perimeter Dike Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	24,879	5.5	136,833	24,879	5.5	136,833
Toe Armor -	24,879	7.0	174,151	24,879	7.0	174,151
Bedding Stone -	24,879	1.0	24,879	24,879	1.0	24,879
Underlayer Stone -	24,879	4.0	99,515	24,879	4.0	99,515
West Dike Armor -	24,879	10.0	248,788	24,879	10.0	248,788
East Dike Armor -	19,619	3.5	68,665	19,619	3.5	68,665
Miscellaneous	LF	SY/LF	SY	LF	SY/LF	SY
Road Stone -	62,126	3.0	186,377	62,126	3.0	186,377
Geotextile -	44,497	13	578,465	44,497	13	578,465

James Island Habitat Development

Table 4 - Preliminary Site Characteristics and Quantities   Alignment No. 4

SITE CHARACTERISTICS	Alignment No. 4 (10 ft)			Alignment No. 4 (20 ft)		
Upland Baseline Area -	1,100	Acres		1,100	Acres	
Upland Baseline Perimeter -	44,730	LF		44,730	LF	
Upland Site Volume below sea level -	16.0	MCY		16.0	MCY	
Upland Site Volume above sea level -	14.2	MCY		31.9	MCY	
Upland Site Volume -	30.2	MCY		47.9	MCY	
Upland Site Capacity -	43.1	MCY		70.4	MCY	
Wetland Baseline Area -	1,100	Acres		1,100	Acres	
Wetland Baseline Perimeter -	43,490	LF		43,490	LF	
Wetland Site Volume below sea level -	5.3	MCY		5.3	MCY	
Wetland Site Volume above sea level -	2.7	MCY		2.7	MCY	
Wetland Site Volume -	8.0	MCY		8.0	MCY	
Wetland Site Capacity -	11.2	MCY		11.2	MCY	
Total Baseline Area -	2,200	Acres		2,200	Acres	
Total Baseline Perimeter -	48,963	LF		48,963	LF	
Total Interior Dike -	19,628	LF		19,628	LF	
Total Volume -	38.2	MCY		55.9	MCY	
Total Site Capacity -	54.3	MCY		81.6	MCY	

QUANTITIES	Alignment No. 4 (10 ft)			Alignment No. 4 (20 ft)		
Hydraulic Fill Material	LF	CY/LF	CY	LF	CY/LF	CY
Unsuitable Backfill -			250,000			250,000
Perimeter Dikes to +08 -	23,862	22.35	533,314	23,862	22.35	533,314
Perimeter Dikes to +10 -	25,101	38.48	965,904			
Perimeter Dikes to +20 -				25,101	89.44	2,245,074
Interior Dikes to +10 -	19,628	35.25	691,898			
Interior Dikes to +20 -				19,628	60.62	1,189,869
Total -	**68,592**		2,441,116	**68,592**		4,218,257
Perimeter Dike Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	29,077	5.5	159,924	29,077	5.5	159,924
Toe Armor -	29,077	7.0	203,540	29,077	7.0	203,540
Bedding Stone -	29,077	1.0	29,077	29,077	1.0	29,077
Underlayer Stone -	29,077	4.0	116,309	29,077	4.0	116,309
West Dike Armor -	29,077	10.0	290,772	29,077	10.0	290,772
East Dike Armor -	19,886	3.5	69,602	19,886	3.5	69,602
Miscellaneous	LF	SY/LF	SY	LF	SY/LF	SY
Road Stone -	68,592	3.0	205,775	68,592	3.0	205,775
Geotextile -	48,963	13	636,524	48,963	13	636,524

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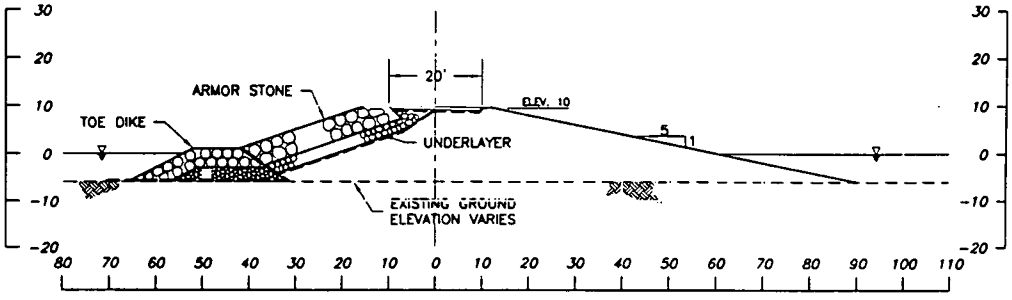
Table 5 - Preliminary Site Characteristics and Quantities Alignment No. 5

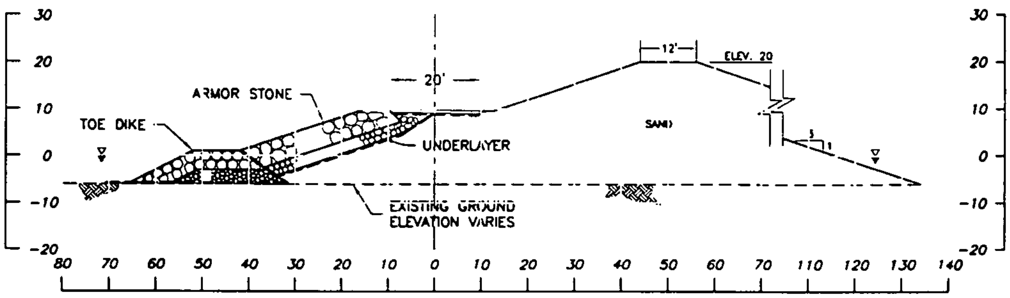
SITE CHARACTERISTICS	Alignment No. 5 (10 ft)		Alignment No. 5 (20 ft)	
Upland Baseline Area -	1,036	Acres	1,036	Acres
Upland Baseline Perimeter -	43,595	LF	43,595	LF
Upland Site Volume below sea level	15.0	MCY	15.0	MCY
Upland Site Volume above sea level	13.4	MCY	30.1	MCY
Upland Site Volume -	28.4	MCY	45.1	MCY
Upland Site Capacity -	40.6	MCY	66.3	MCY
Wetland Baseline Area -	1,036	Acres	1,036	Acres
Wetland Baseline Perimeter -	39,053	LF	39,053	LF
Wetland Site Volume below sea level	5.0	MCY	5.0	MCY
Wetland Site Volume above sea level	2.5	MCY	2.5	MCY
Wetland Site Volume -	7.5	MCY	7.5	MCY
Wetland Site Capacity -	10.5	MCY	10.5	MCY
Total Baseline Area -	2,072	Acres	2,072	Acres
Total Baseline Perimeter -	45,587	LF	45,587	LF
Total Interior Dike -	18,530	LF	18,530	LF
Total Volume -	35.9	MCY	52.6	MCY
Total Site Capacity -	51.2	MCY	76.9	MCY

QUANTITIES	Alignment No. 5 (10 ft)			Alignment No. 5 (20 ft)		
Hydraulic Fill Material	LF	CY/LF	CY	LF	CY/LF	CY
Unsuitable Backfill -			250,000			250,000
Perimeter Dikes to +08 -	20,523	22.35	458,681	20,523	22.35	458,681
Perimeter Dikes to +10 -	25,064	38.48	964,472			
Perimeter Dikes to +20 -				25,064	89.44	2,241,745
Interior Dikes to +10 -	18,530	35.25	653,198			
Interior Dikes to +20 -				18,530	60.62	1,123,316
Total -	**64,117**		2,326,351	**64,117**		4,073,742
Perimeter Dike Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	28,957	5.5	159,266	28,957	5.5	159,266
Toe Armor -	28,957	7.0	202,702	28,957	7.0	202,702
Bedding Stone -	28,957	1.0	28,957	28,957	1.0	28,957
Underlayer Stone -	28,957	4.0	115,830	28,957	4.0	115,830
West Dike Armor -	28,957	10.0	289,575	28,957	10.0	289,575
East Dike Armor -	16,629	3.5	58,203	16,629	3.5	58,203
Miscellaneous	LF	SY/LF	SY	LF	SY/LF	SY
Road Stone -	64,117	3.0	192,352	64,117	3.0	192,352
Geotextile -	45,587	13	592,629	45,587	13	592,629

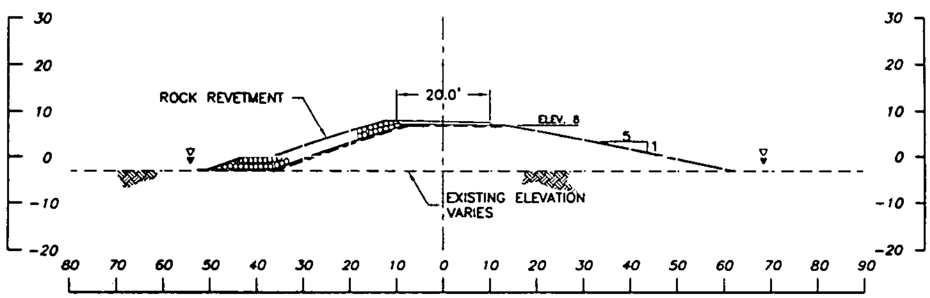
FIGURE 7 – JAMES ISLAND TYPICAL EXTERIOR DIKE SECTIONS



TYPICAL WEST DIKE (10 FT)
SCALE: 1" = 40'

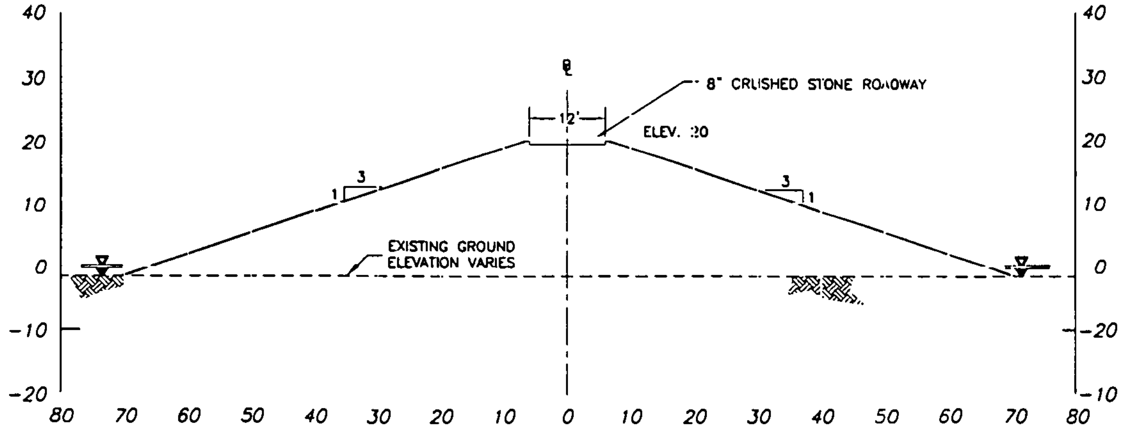


TYPICAL WEST DIKE (20 FT)
SCALE: 1" = 40'

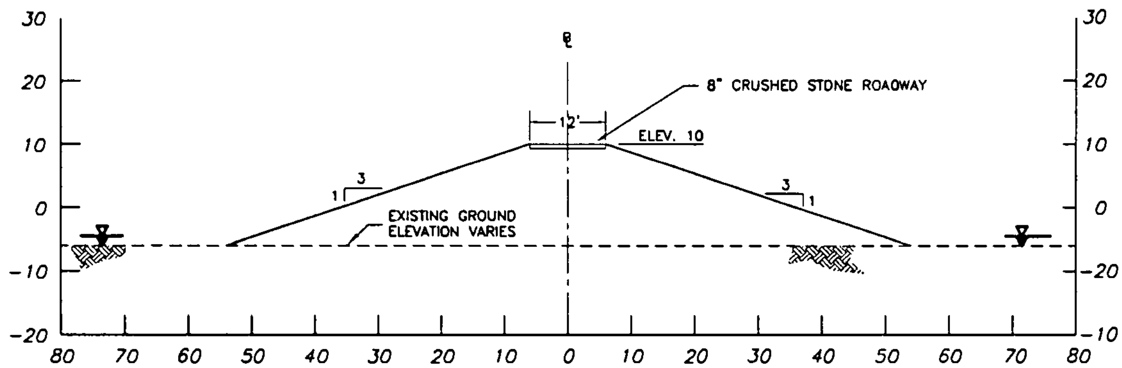


TYPICAL EAST DIKE (8 FT)
SCALE: 1" = 40'

FIGURE 8 – JAMES ISLAND TYPICAL INTERIOR DIKE SECTIONS



TYPICAL INTERIOR DIKE SECTION (10 FT)
SCALE: 1" = 20'



TYPICAL INTERIOR DIKE SECTION (10 FT)
SCALE: 1" = 20'

4.0 ALTERNATIVE BORROW METHODS

The estimated neat sand fill quantities for construction of James Island are provided in Appendix A Tables A-1 thru A-5 and are summarized as follows: dike alignment no. 1 quantities for +/- 10 ft dike height are 1.7 million cubic yards and 20 ft dike height are 2.9 million cubic yards (Table A-1), dike alignment no. 2 quantities for +/- 10 ft dike height are 2.4 million cubic yards and 20 ft dike height are 4.0 million cubic yards (Table A-2), dike alignment no. 3 quantities for +/- 10 ft dike height are 2.2 million cubic yards and 20 ft dike height are 3.8 million cubic yards (Table A-3), dike alignment no. 4 quantities for +/- 10 ft dike height are 2.4 million cubic yards and 20 ft dike height are 4.2 million cubic yards (Table A-4), and dike alignment no. 5 quantities for +/- 10 ft dike height are 2.4 million cubic yards and 20 ft dike height are 4.2 million cubic yards (Table A-5). In addition to fill for the perimeter dike, this estimate includes sand for interior dikes to divide the island into cells, and sand to backfill unsuitable foundation areas along the perimeter dike.

Geotechnical field studies were not performed, thus these borrow options were the methods investigated. Four different methods for providing sand borrow have been considered to meet the estimated quantities: (1) mine sand from a land based quarry and transport it by truck (2) mine sand from a quarry and transport it by barge (3) dredge and transport off-site sand by hopper dredge to an openwater placement site and place sand in dikes with a hydraulic dredge (4) hydraulic dredge directly from on-site borrow area.

Alternative borrow method 1 uses the closest sand and gravel quarry to James Island is Shufelt Sand & Gravel four miles east of Cambridge, which is 20 miles from James Island by truck. The estimated hauling cost for the 48 mile round trip would be about $25/CY. This does not include the cost of the sand, which may not be available in the quantities required. In addition to the high cost, there is the logistical problem of finding enough trucks to keep the construction on schedule, and potential traffic problems on Route 50 especially during the summer months. Also, a causeway would have to be built to James Island from Taylors Island (except for alignment 4), which would increase sand volumes and block boat traffic. This was not considered economically feasible.

Alternative borrow method 2 is not feasible without a local quarry adjacent to deep water. However, trucking the borrow material to a deep-water facility and transferring it to barges could take place in Cambridge, a ten mile round trip from the quarry in alternative borrow method 1. The barge would then make a 50 mile round trip to James Island and back. This was not considered economically feasible.

Alternative borrow method 3 assumes that suitable fill material is not available within two or three miles and must be transported by hopper dredge from about 40 nautical miles away from Craighill Channel. After transport, the material is bottom released in an openwater stockpile located on site and pumped into section by a small hydraulic dredge. Costs are provided for this borrow method.

Alternative borrow method 4, assumes suitable on site sand fill is pumped to a stockpile and then hauled, shaped into section and armored. This method of dike building was used to construct the Poplar Island Habitat Restoration site. Costs are provided for this borrow method.

5.0 COST ANALYSIS

The preliminary construction costs for James Island were determined by using the configurations described in the previous sections. Unit prices were estimated based on actual bid prices for similar construction projects at Poplar Island. The preliminary construction costs for the five dike alignments are presented in Appendix A - Tables A-1 thru A-5. The preliminary construction costs are broken down by line item, borrow source and dike height (20 alternatives). Line items include: mobilization and demobilization, roadway stone, geotextile filter fabric, one personnel pier, excavation and backfill for weak unsuitable foundation material, various layers of toe dike and slope stones, spillway structures to convey decant and rain water within cells and directly to the bay, nursery planting and suitable dike core fill material. In addition to preliminary construction costs, study costs (engineering planning and design costs) were estimated to develop an "initial construction cost".

The initial construction costs include preliminary construction plus conceptual, pre-feasibility and feasibility study costs, and are summarized below. Table 6 outlines the 20 alternative Initial Construction Costs (from Appendix B – Tables B1 thru B20 – Item A). This matrix of costs range from $49.9 million at $2.11 per cy of capacity (alignment 1, +10, borrow #4) to $90.4 million at $1.11 per cy of capacity (alignment 4, +20, borrow #3). The lowest unit cost option has an initial construction cost of $81.9 million at $1.00 per cy of capacity (alignment 4, +20, borrow #4).

Table 6 - Summary Of Initial Construction Costs

	+10--Borrow # 3		+10--Borrow # 4		+20--Borrow # 3		+20--Borrow # 4	
Alignment No.	Initial Construction Cost $Million	Unit Cost $/Cy	Initial Construction Cost $Million	Unit Cost $/Cy	Initial Construction Cost $Million	Unit Cost $/Cy	Initial Construction Cost $Million	Unit Cost $/Cy
1	$53.3	$2.26	$49.9	$2.11	$65.3	$1.82	$59.5	$1.66
2	$73.2	$1.34	$68.5	$1.25	$89.9	$1.11	$81.8	$1.01
3	$65.5	$1.71	$61.1	$1.60	$80.9	$1.39	$73.4	$1.27
4	$73.7	$1.36	$68.8	$1.27	$90.4	$1.11	$81.9	$1.00
5	$73.1	$1.43	$68.3	$1.33	$89.8	$1.17	$81.4	$1.06

Note: Initial Construction Costs include preliminary construction plus study costs (see Tables B-1 Thru B-20 Item A).
Unit Cost is expressed in dollars per cubic yard of capacity.

The Total Site Use costs were also developed for each dike alignment, borrow source and dike height. The estimated total site use costs for each alternative are presented in Appendix B - Tables B-1 thru B-20 – Items A thru D. Total site use costs include: initial construction cost (described above); site development cost (dredge material management, site maintenance and site monitoring and reporting); habitat development cost (plans and design, monitoring, implementation, and operation & maintenance); and dredging, transport and placement cost. Table 7 outlines the 20 alternative Total Site Use Costs. This matrix of costs range from $372 million at $15.74 per cy of capacity (alignment 1, +10, borrow #4) to $1.222 billion at $14.97 per cy of capacity (alignment 4, +20, borrow #3). The lowest unit cost option has a total site use cost of $1.136 billion at $14.78 per cy of capacity (alignment 4, +20, borrow #4).

Table 7 - Summary Of Total Site Use Costs

	+10--Borrow # 3		+10--Borrow # 4		+20--Borrow # 3		+20--Borrow # 4	
Alignment No.	Total Site Use Cost $Million	Unit Cost $/Cy	Total Site Use Cost $Million	Unit Cost $/Cy	Total Site Use Cost $Million	Unit Cost $/Cy	Total Site Use Cost $Million	Unit Cost $/Cy
1	$375.5	$15.91	$371.5	$15.74	$541.3	$15.12	$534.6	$14.93
2	$840.3	$15.33	$834.9	$15.23	$1,213.5	$14.94	$1,204.2	$14.83
3	$600.2	$15.67	$595.1	$15.54	$873.4	$15.06	$864.8	$14.91
4	$838.8	$15.45	$833.1	$15.34	$1,221.5	$14.97	$1,211.8	$14.85
5	$791.1	$15.45	$785.5	$15.34	$1,145.9	$14.90	$1,136.2	$14.78

Note Total Site Use Costs include: Initial Construction, Site Development, Habitat Development and Dredging/Placement (see Table B-1 Thru B-20 Items A thru D).
Unit Cost is expressed in dollars per cubic yard of capacity.

Certain factors may change the costs estimated in this report. A 15% contingency cost is included to offset unforeseen developments. For example, construction industry conditions and fuel prices drive the cost of construction, dredging, transport and placement. Also, the limited available geotechnical information at this time may be a likely source of adjustments in estimated costs. The cost estimates in this study were conducted at a conceptual level and therefore, the results should be considered preliminary. Pre-feasibility, feasibility and engineering design studies would be required to assess detailed project costs.

6.0 SUMMARY & CONCLUSIONS

The range of costs for Total Site Use is about $372 million to $1.22 billion. The schedule for construction is about 1 – 3 years, depending on the borrow method used. The easiest, quickest and least costly borrow source would be if onsite borrow material is available, (alternative borrow method 4) resulting in construction times closer to one year, which would be considerably less than any of the other borrow alternatives.

When all factors associated with moving dredged material from the Baltimore Harbor channels to the James Island Habitat Restoration Site are considered, the Total costs per cubic yard of site capacity range from $14.78/cy to $15.91/cy.

6.1 Alignment No. 1 General Site Characteristics

- Water depth is approximately 3.5 - 8 ft. Average water depth is 6 ft.
- Site area is 978 acres
- Site perimeter is 32,102 L.Ft.
- The site area to perimeter ratio is .031 ac/L.Ft.
- Site capacity is 23.6 to 35.8 Mcy
- Site life is 10 to 15 years
- Lowest total initial construction cost, but highest unit cost
- Lowest total site use cost, but highest unit cost

6.2 Alignment No. 2 General Site Characteristics

- Water depth is approximately 5 - 8 ft. Average water depth is 6.5 ft.
- Site area is 2126 acres
- Site perimeter is 43,310 L.Ft.
- The site area to perimeter ratio is .049 ac/L.Ft.
- Site capacity is 54.8 to 81.2 Mcy
- Site life is 22 to 33 years
- Alignments 2, 4 and 5 are highest total initial construction cost, but lowest unit cost
- Alignments 2, 4 and 5 are highest total site use cost, but lowest unit cost

6.3 Alignment No. 3 General Site Characteristics

- Water depth is approximately 4.5 - 7 ft. Average water depth is 6 ft.
- Site area is 1586 acres
- Site perimeter is 44,497 L.Ft.
- The site area to perimeter ratio is .036 ac/L.Ft.
- Site capacity is 38.3 to 58.0 Mcy
- Site life is 16 to 24 years
- Medium total initial construction cost, and medium unit cost
- Medium total site use cost, and medium unit cost

6.4 Alignment No. 4 General Site Characteristics

- Water depth is approximately 3 - 9 ft. Average water depth is 6 ft.
- Site area is 2200 acres
- Site perimeter is 48,963 L.Ft.
- The site area to perimeter ratio is .045 ac/L.Ft.
- Site capacity is 54.3 to 81.6 Mcy
- Site life is 22 to 33 years
- Alignments 2, 4 and 5 are highest total initial construction cost, but lowest unit cost
- Alignments 2, 4 and 5 are highest total site use cost, but lowest unit cost

6.5 Alignment No. 5 General Site Characteristics

- Water depth is approximately 3 - 9 ft. Average water depth is 6 ft.
- Site area is 2072 acres
- Site perimeter is 45,587 L.Ft.
- The site area to perimeter ratio is .045 ac/L.Ft.
- Site capacity is 51.2 to 76.9 Mcy
- Site life is 21 to 31 years
- Alignments 2, 4 and 5 are highest total initial construction cost, but lowest unit cost
- Alignments 2, 4 and 5 are highest total site use cost, but lowest unit cost

7.0 REFERENCES

GBA (2001) Conceptual/Prefeasibility Study for Dredged Material Placement Site Construction at Parsons Island. Gahagan & Bryant Associates, Inc., Baltimore, MD.

APPENDIX A

PRELIMINARY CONSTRUCTION COSTS

James Island Habitat Development

Table A-1 - Preliminary Construction Costs Alignment No. 1*

	Unit	Unit Rate	Alignment No. 1 (10 FT) Qty	Cost $	Alignment No. 1 (20 FT) Qty	Cost $
Mobilization/Demobilization	L.S.	$4,500,000	Job	$4,500,000	Job	$4,500,000
Road Stone	S.Y.	$11.00	135,510	$1,490,615	135,510	$1,490,615
Geotextile	S.Y.	$3.50	417,327	$1,460,646	417,327	$1,460,646
Personnel Pier	L.S.	$500,000	Job	$500,000	Job	$500,000
Unsuitable Foundation Excavation	C.Y.	$8.00	250,000	$2,000,000	250,000	$2,000,000
Stone Work						
Quarry Run	Ton	$30.00	110,470	$3,314,103	110,470	$3,314,103
Toe Armor	Ton	$40.00	140,598	$5,623,932	140,598	$5,623,932
Bedding Stone	Ton	$35.00	20,085	$702,992	20,085	$702,992
Underlayer	Ton	$35.00	80,342	$2,811,966	80,342	$2,811,966
East Dike Armor Stone	Ton	$35.00	42,058	$1,472,037	42,058	$1,472,037
West/North Dike Armor Stone	Ton	$40.00	200,855	$8,034,189	200,855	$8,034,189
Spillways	Each	$200,000	6	$1,200,000	6	$1,200,000
Nursery Planting	L.S.	$200,000	Job	$200,000	Job	$200,000
SUBTOTAL				$33,310,480		$33,310,480
Borrow Alternative 3 (offsite)						
Transport by hopper dredge	C.Y.	$3.00	1,701,661	$5,104,984	2,897,371	$8,692,112
Dike Fill Hydraulically from Hopper	C.Y.	$7.00	1,701,661	$11,911,629	2,897,371	$20,281,594
A3 GRAND TOTAL				**$50,327,092**		**$62,284,185**
per CY of Site Capacity				$2.13		$1.74
Borrow Alternative 4 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	$8.00	1,701,661	$13,613,290	2,897,371	$23,178,964
A4 GRAND TOTAL				**$46,923,770**		**$56,489,444**
per CY of Site Capacity				$1.99		$1.58

* Costs are estimated in 2001 dollars.

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Table A-2 - Preliminary Construction Costs Alignment No. 2*

	Unit	Unit Rate	Alignment No. 2 (10 FT) Qty	Cost $	Alignment No. 2 (20 FT) Qty	Cost $
Mobilization/Demobilization	L.S.	$5,000,000	Job	$5,000,000	Job	$5,000,000
Road Stone	S.Y.	$11.00	200,910	$2,210,012	200,910	$2,210,012
Geotextile	S.Y.	$3.50	634,552	$2,220,933	634,552	$2,220,933
Personnel Pier	L.S.	$500,000	Job	$500,000	Job	$500,000
Unsuitable Foundation Excavation	C.Y.	$8.00	250,000	$2,000,000	250,000	$2,000,000
Stone Work						
Quarry Run	Ton	$30.00	162,201	$4,866,037	162,201	$4,866,037
Toe Armor	Ton	$40.00	206,438	$8,257,518	206,438	$8,257,518
Bedding Stone	Ton	$35.00	29,491	$1,032,190	29,491	$1,032,190
Underlayer	Ton	$35.00	117,965	$4,128,759	117,965	$4,128,759
East Dike Armor Stone	Ton	$35.00	67,622	$2,366,771	67,622	$2,366,771
West/North Dike Armor Stone	Ton	$40.00	294,911	$11,796,454	294,911	$11,796,454
Spillways	Each	$200,000	10	$2,000,000	10	$2,000,000
Nursery Planting	L.S.	$200,000	Job	$200,000	Job	$200,000
SUBTOTAL				$46,578,675		$46,578,675
Borrow Alternative 3 (offsite)						
Transport by hopper dredge	C.Y.	$3.00	2,362,659	$7,087,976	4,029,048	$12,087,143
Dike Fill Hydraulically from Hopper	C.Y.	$7.00	2,362,659	$16,538,611	4,029,048	$28,203,334
A3 GRAND TOTAL				**$70,205,263**		**$86,869,153**
per CY of Site Capacity				$1.28		$1.07
Borrow Alternative 4 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	$8.00	2,362,659	$18,901,270	4,029,048	$32,232,382
A4 GRAND TOTAL				**$65,479,945**		**$78,811,057**
per CY of Site Capacity				$1.20		$0.97

* Costs are estimated in 2001 dollars.

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Table A-3 - Preliminary Construction Costs Alignment No.3*

	Unit	Unit Rate	Alignment No. 3 (10 FT) Qty	Alignment No. 3 (10 FT) Cost $	Alignment No. 3 (20 FT) Qty	Alignment No. 3 (20 FT) Cost $
Mobilization/Demobilization	L.S.	$5,000,000	Job	$5,000,000	Job	$5,000,000
Road Stone	S.Y.	$11.00	135,510	$1,490,615	135,510	$1,490,615
Geotextile	S.Y.	$3.50	417,327	$1,460,646	417,327	$1,460,646
Personnel Pier	L.S.	$500,000	Job	$500,000	Job	$500,000
Unsuitable Foundation Excavation	C.Y.	$8.00	250,000	$2,000,000	250,000	$2,000,000
Stone Work						
Quarry Run	Ton	$30.00	136,833	$4,104,999	136,833	$4,104,999
Toe Armor	Ton	$40.00	174,151	$6,966,058	174,151	$6,966,058
Bedding Stone	Ton	$35.00	24,879	$870,757	24,879	$870,757
Underlayer	Ton	$35.00	99,515	$3,483,029	99,515	$3,483,029
East Dike Armor Stone	Ton	$35.00	68,665	$2,403,267	68,665	$2,403,267
West/North Dike Armor Stone	Ton	$40.00	248,788	$9,951,512	248,788	$9,951,512
Spillways	Each	$200,000	10	$2,000,000	10	$2,000,000
Nursery Planting	L.S.	$200,000	Job	$200,000	Job	$200,000
SUBTOTAL				$40,430,882		$40,430,882

Borrow Alternative 3 (offsite)						
Transport by hopper dredge	C.Y.	$3.00	2,211,393	$6,634,178	3,750,107	$11,250,320
Dike Fill Hydraulically from Hopper	C.Y	$7.00	2,211,393	$15,479,748	3,750,107	$26,250,746
A3 GRAND TOTAL				**$62,544,809**		**$77,931,949**
per CY of Site Capacity				$1.63		$1.34
Borrow Alternative 4 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	$8.00	2,211,393	$17,691,141	3,750,107	$30,000,853
A4 GRAND TOTAL				**$58,122,023**		**$70,431,735**
per CY of Site Capacity				$1.52		$1.21

* Costs are estimated in 2001 dollars.

James Island Habitat Development

Table A-4 - Preliminary Construction Costs Alignment No. 4*

	Unit	Unit Rate	Alignment No. 4 (10 FT) Qty	Alignment No. 4 (10 FT) Cost $	Alignment No. 4 (20 FT) Qty	Alignment No. 4 (20 FT) Cost $
Mobilization/Demobilization	L.S.	$5,000,000	Job	$5,000,000	Job	$5,000,000
Road Stone	S.Y.	$11.00	205,775	$2,263,526	205,775	$2,263,526
Geotextile	S.Y.	$3.50	636,524	$2,227,833	636,524	$2,227,833
Personnel Pier	L.S.	$500,000	Job	$500,000	Job	$500,000
Unsuitable Foundation Excavation	C.Y.	$8.00	250,000	$2,000,000	250,000	$2,000,000
Stone Work						
Quarry Run	Ton	$30.00	159,924	$4,797,730	159,924	$4,797,730
Toe Armor	Ton	$40.00	203,540	$8,141,603	203,540	$8,141,603
Bedding Stone	Ton	$35.00	29,077	$1,017,700	29,077	$1,017,700
Underlayer	Ton	$35.00	116,309	$4,070,801	116,309	$4,070,801
East Dike Armor Stone	Ton	$35.00	69,602	$2,436,062	69,602	$10,177,004
West/North Dike Armor Stone	Ton	$40.00	290,772	$11,630,861	290,772	$2,784,071
Spillways	Each	$200,000	10	$2,000,000	10	$2,000,000
Nursery Planting	L.S.	$200,000	Job	$200,000	Job	$200,000
SUBTOTAL				$46,286,118		$45,180,269
Borrow Alternative 3 (offsite)						
Transport by hopper dredge	C.Y.	$3.00	2,441,116	$7,323,349	4,218,257	$12,654,770
Dike Fill Hydraulically from Hopper	C.Y.	$7.00	2,441,116	$17,087,813	4,218,257	$29,527,796
A3 GRAND TOTAL				**$70,697,279**		**$87,362,835**
per CY of Site Capacity				$1.30		$1.07
Borrow Alternative 4 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	$8.00	2,441,116	$19,528,929	4,218,257	$33,746,053
A4 GRAND TOTAL				**$65,815,047**		**$78,926,322**
per CY of Site Capacity				$1.21		$0.97

* Costs are estimated in 2001 dollars.

James Island Habitat Development

Table A-5 - Preliminary Construction Costs Alignment No. 5*

	Unit	Unit Rate	Alignment No. 5 (10 FT) Qty	Cost $	Alignment No. 5 (20 FT) Qty	Cost $
Mobilization/Demobilization	L.S.	$5,000,000	Job	$5,000,000	Job	$5,000,000
Road Stone	S.Y.	$11.00	205,775	$2.263,526	205,775	$2,263,526
Geotextile	S.Y.	$3.50	636.524	$2,227,833	636,524	$2,227,833
Personnel Pier	L.S.	$500,000	Job	$500,000	Job	$500,000
Unsuitable Foundation Excavation	C.Y.	$8.00	250,000	$2,000,000	250,000	$2,000,000
Stone Work						
Quarry Run	Ton	$30.00	159,266	$4,777,982	159,266	$4,777,982
Toe Armor	Ton	$40.00	202,702	$8,108,091	202,702	$8,108,091
Bedding Stone	Ton	$35.00	28,957	$1,013,511	28,957	$1,013,511
Underlayer	Ton	$35.00	115,830	$4,054,046	115,830	$4,054,046
East Dike Armor Stone	Ton	$35.00	58,203	$2,037,103	58.203	$10,135.114
West/North Dike Armor Stone	Ton	$40.00	289,575	$11,582,988	289,575	$2.328,117
Spillways	Each	$200,000	10	$2,000,000	10	$2,000,000
Nursery Planting	L.S.	$200,000	Job	$200,000	Job	$200,000
SUBTOTAL				$45,765,081		$44,608,222

Borrow Alternative 3 (offsite)						
Transport by hopper dredge	C.Y.	$3.00	2,441,116	$7,323,349	4,218,257	$12,654,770
Dike Fill Hydraulically from Hopper	C.Y.	$7.00	2,441,116	$17,087,813	4,218,257	$29,527,796
A3 GRAND TOTAL				**$70,176,243**		**$86,790,788**
per CY of Site Capacity				$1.37		$1.13
Borrow Alternative 4 (onsite)						
Dike Fill Hydraulically from Onsite	C.Y.	$8.00	2,441,116	$19,528,929	4,218,257	$33,746,053
A4 GRAND TOTAL				**$65,294,010**		**$78,354,275**
per CY of Site Capacity				$1.28		$1.02

* Costs are estimated in 2001 dollars.

APPENDIX B

TOTAL SITE USE COST ANALYSIS

JAMES ISLAND HABITAT DEVELOPMENT

Table B-1 - Total site use cost analysis for Dike Alignment No. 1 - (10 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	23.6	Site Surface Area (Ac)	978
Site Operating Life (Years)	10	Site Perimeter Dike (Ft)	32,102
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	13,068
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**23.6**	**MCY**	**$2.26**	**$53,327,092**	
Initial Construction Costs				$50,327,092	Refer to Table 6, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs
B. Site Development Costs			**$3,313,145**	**$38,225,634**	
Dredged Material Management	10.0	Year	$1,103,550	$11,035,500	Placement, dewatering and crust management costs for the operating life $150,000+ ($975 per Acre)
Site Maintenance	12.0	Year	$1,534,595	$18,415,134	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	13.0	Year	$675,000	$8,775,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$20,237,200**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	10.0	Year	$500,000	$5,000,000	
Implementation				$7,237,200	
Channels	489	Acre	$6,000	$2,934,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting Seeding	978	Acre	$4,400	$4,303,200	$4,400 per acre
Operation & Maintenance	10.0	Year	$500,000	$5,000,000	
D. Dredging, Transportation & Placement Costs				**$214,700,000**	
Mob and Demob	10.0	Year	$2,000,000	$20,000,000	Mob & Demob for operating life of site
Dredging	23.6	Mcy	$2.00	$47,200,000	Clamshell Dredging
Transport	23.6	Mcy	$4.00	$94,400,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	23.6	Mcy	$2.25	$53,100,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$326,489,926**	
Contingency	15.00%			$48,973,489	
TOTAL COST A+B+C+D				**$375,463,415**	
TOTAL UNIT COST				**$15.91**	**per cubic yard**

* Costs are estimated in 2001 dollars

JAMES ISLAND HABITAT DEVELOPMENT

Table B-2 - Total site use cost analysis for Dike Alignment No. 1 - (10 FT) - Borrow Alternative No.4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	23.6	Site Surface Area (Ac)	978
Site Operating Life (Years)	10	Site Perimeter Dike (Ft)	32,102
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	13,068
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**23.6**	**MCY**	**$2.12**	**$49,923,770**	
Initial Construction Costs				$46,923,770	Refer to Table 6, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$3,313,145**	**$38,225,634**	
Dredged Material Management	10.0	Year	$1,103,550	$11,035,500	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	12.0	Year	$1,534,595	$18,415,134	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	13.0	Year	$675,000	$8,775,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$20,237,200**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	10.0	Year	$500,000	$5,000,000	
Implementation				$7,237,200	
Channels	489	Acre	$6,000	$2,934,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	978	Acre	$4,400	$4,303,200	$4,400 per acre
Operation & Maintenance	10.0	Year	$500,000	$5,000,000	
D. Dredging, Transportation & Placement Costs				**$214,700,000**	
Mob and Demob	10.0	Year	$2,000,000	$20,000,000	Mob & Demob for operating life of site
Dredging	23.6	Mcy	$2.00	$47,200,000	Clamshell Dredging
Transport	23.6	Mcy	$4.00	$94,400,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	23.6	Mcy	$2.25	$53,100,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$323,086,604**	
Contingency	15.00%			$48,462,991	
TOTAL COST A+B+C+D				**$371,549,595**	
TOTAL UNIT COST				**$15.74**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-3 - Total site use cost analysis for Dike Alignment No. 1 - (20 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	35.8	Site Surface Area (Ac)	978
Site Operating Life (Years)	15	Site Perimeter Dike (Ft)	32,102
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	13,068
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**35.8**	**MCY**	**$1.82**	**$65,284,185**	
Initial Construction Costs				$62,284,185	Refer to Table 6, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$3,313,145**	**$54,791,357**	
Dredged Material Management	15.0	Year	$1,103,550	$16,553,250	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	17.0	Year	$1,534,595	$26,088,107	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	18.0	Year	$675,000	$12,150,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$25,237,200**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	15.0	Year	$500,000	$7,500,000	
Implementation				$7,237,200	
Channels	489	Acre	$6,000	$2,934,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	978	Acre	$4,400	$4,303,200	$4,400 per acre
Operation & Maintenance	15.0	Year	$500,000	$7,500,000	
D. Dredging, Transportation & Placement Costs				**$325,350,000**	
Mob and Demob	15.0	Year	$2,000,000	$30,000,000	Mob & Demob for operating life of site
Dredging	35.8	Mcy	$2.00	$71,600,000	Clamshell Dredging
Transport	35.8	Mcy	$4.00	$143,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	35.8	Mcy	$2.25	$80,550,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$470,662,742**	
Contingency	15.00%			$70,599,411	
TOTAL COST A+B+C+D				**$541,262,154**	
TOTAL UNIT COST				**$15.12**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-4 - Total site use cost analysis for Dike Alignment No. 1 - (20 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	35.8	Site Surface Area (Ac)	978
Site Operating Life (Years)	15	Site Perimeter Dike (Ft)	32,102
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	13,068
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**35.8**	**MCY**	**$1.66**	**$59,489,444**	
Initial Construction Costs				$56,489,444	Refer to Table 6, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$3,313,145**	**$54,791,357**	
Dredged Material Management	15.0	Year	$1,103,550	$16,553,250	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	17.0	Year	$1,534,595	$26,088,107	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	18.0	Year	$675,000	$12,150,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$25,237,200**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	15.0	Year	$500,000	$7,500,000	
Implementation				$7,237,200	
Channels	489	Acre	$6,000	$2,934,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	978	Acre	$4,400	$4,303,200	$4,400 per acre
Operation & Maintenance	15.0	Year	$500,000	$7,500,000	
D. Dredging, Transportation & Placement Costs				**$325,350,000**	
Mob and Demob	15.0	Year	$2,000,000	$30,000,000	Mob & Demob for operating life of site
Dredging	35.8	Mcy	$2.00	$71,600,000	Clamshell Dredging
Transport	35.8	Mcy	$4.00	$143,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	35.8	Mcy	$2.25	$80,550,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$464,868,001**	
Contingency	15.00%			$69,730,200	
TOTAL COST A+B+C+D				**$534,598,201**	
TOTAL UNIT COST				**$14.93**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-5 - Total site use cost analysis for Dike Alignment No. 2 - (10 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	54.8	Site Surface Area (Ac)	2,126
Site Operating Life (Years)	22	Site Perimeter Dike (Ft)	48,812
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,158
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**54.8**	**MCY**	**$1.34**	**$73,205,263**	
Initial Construction Costs				$70,205,263	Refer to Table 7, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$5,184,390**	**$120,654,660**	
Dredged Material Management	22.0	Year	$2,222,850	$48,902,700	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Aerc)
Site Maintenance	24.0	Year	$2,286,540	$54,876,960	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	25.0	Year	$675,000	$16,875,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$40,732,400**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	22.0	Year	$500,000	$11,000,000	
Implementation				$15,732,400	
Channels	1063	Acre	$6,000	$6,378,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2126	Acre	$4,400	$9,354,400	$4,400 per acre
Operation & Maintenance	22.0	Year	$500,000	$11,000,000	
D. Dredging, Transportation & Placement Costs				**$496,100,000**	
Mob and Demob	22.0	Year	$2,000,000	$44,000,000	Mob & Demob for operating life of site
Dredging	54.8	Mcy	$2.00	$109,600,000	Clamshell Dredging
Transport	54.8	Mcy	$4.00	$219,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	54.8	Mcy	$2.25	$123,300,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$730,692,323**	
Contingency	15.00%			$109,603,848	
TOTAL COST A+B+C+D				**$840,296,171**	
TOTAL UNIT COST				**$15.33**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-6 - Total site use cost analysis for Dike Alignment No. 2 - (10 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	54.8	Site Surface Area (Ac)	2,126
Site Operating Life (Years)	22	Site Perimeter Dike (Ft)	48,812
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,158
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**54.8**	**MCY**	**$1.25**	**$68,479,945**	
Initial Construction Costs				$65,479,945	Refer to Table 7, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$5,184,390**	**$120,654,660**	
Dredged Material Management	22.0	Year	$2,222,850	$48,902,700	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	24.0	Year	$2,286,540	$54,876,960	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	25.0	Year	$675,000	$16,875,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$40,732,400**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	22.0	Year	$500,000	$11,000,000	
Implementation				$15,732,400	
Channels	1063	Acre	$6,000	$6,378,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2126	Acre	$4,400	$9,354,400	$4,400 per acre
Operation & Maintenance	22.0	Year	$500,000	$11,000,000	
D. Dredging, Transportation & Placement Costs				**$496,100,000**	
Mob and Demob	22.0	Year	$2,000,000	$44,000,000	Mob & Demob for operating life of site
Dredging	54.8	Mcy	$2.00	$109,600,000	Clamshell Dredging
Transport	54.8	Mcy	$4.00	$219,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	54.8	Mcy	$2.25	$123,300,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$725,967,005**	
Contingency	15.00%			$108,895,051	
TOTAL COST A+B+C+D				**$834,862,056**	
TOTAL UNIT COST				**$15.23**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-7 - Total site use cost analysis for Dike Alignment No. 2 - (20 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	81.2	Site Surface Area (Ac)	2,126
Site Operating Life (Years)	33	Site Perimeter Dike (Ft)	48,812
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,158
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**81.2**	**MCY**	**$1.11**	**$89,869,153**	
Initial Construction Costs				$86,869,153	Refer to Table 7, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$5,184,390**	**$177,682,950**	
Dredged Material Management	33.0	Year	$2,222,850	$73,354,050	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	35.0	Year	$2,286,540	$80,028,900	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	36.0	Year	$675,000	$24,300,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$51,732,400**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	33.0	Year	$500,000	$16,500,000	
Implementation				$15,732,400	
Channels	1063	Acre	$6,000	$6,378,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2126	Acre	$4,400	$9,354,400	$4,400 per acre
Operation & Maintenance	33.0	Year	$500,000	$16,500,000	
D. Dredging, Transportation & Placement Costs				**$735,900,000**	
Mob and Demob	33.0	Year	$2,000,000	$66,000,000	Mob & Demob for operating life of site
Dredging	81.2	Mcy	$2.00	$162,400,000	Clamshell Dredging
Transport	81.2	Mcy	$4.00	$324,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	81.2	Mcy	$2.25	$182,700,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$1,055,184,503**	
Contingency	15.00%			$158,277,675	
TOTAL COST A+B+C+D				**$1,213,462,178**	
TOTAL UNIT COST				**$14.94**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-8 - Total site use cost analysis for Dike Alignment No. 2 - (20 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	81.2	Site Surface Area (Ac)	2,126
Site Operating Life (Years)	33	Site Perimeter Dike (Ft)	48,812
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,158
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**81.2**	**MCY**	**$1.01**	**$81,811,057**	
Initial Construction Costs				$78,811,057	Refer to Table 7, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$5,184,390**	**$177,682,950**	
Dredged Material Management	33.0	Year	$2,222,850	$73,354,050	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	35.0	Year	$2,286,540	$80,028,900	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	36.0	Year	$675,000	$24,300,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$51,732,400**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	33.0	Year	$500,000	$16,500,000	
Implementation				$15,732,400	
Channels	1063	Acre	$6,000	$6,378,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2126	Acre	$4,400	$9,354,400	$4,400 per acre
Operation & Maintenance	33.0	Year	$500,000	$16,500,000	
D. Dredging, Transportation & Placement Costs				**$735,900,000**	
Mob and Demob	33.0	Year	$2,000,000	$66,000,000	Mob & Demob for operating life of site
Dredging	81.2	Mcy	$2.00	$162,400,000	Clamshell Dredging
Transport	81.2	Mcy	$4.00	$324,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	81.2	Mcy	$2.25	$182,700,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$1,047,126,407**	
Contingency	15.00%			$157,068,961	
TOTAL COST A+B+C+D				**$1,204,195,368**	
TOTAL UNIT COST				**$14.83**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-9 - Total site use cost analysis for Dike Alignment No. 3 - (10 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	38.3	Site Surface Area (Ac)	1,586
Site Operating Life (Years)	16	Site Perimeter Dike (Ft)	44,497
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	17,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**38.3**	**MCY**	**$1.71**	**$65,544,809**	
Initial Construction Costs				$62,544,809	Refer to Table 8, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$4,463,715**	**$77,629,170**	
Dredged Material Management	16.0	Year	$1,696,350	$27,141,600	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	18.0	Year	$2,092,365	$37,662,570	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	19.0	Year	$675,000	$12,825,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$30,736,400**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	16.0	Year	$500,000	$8,000,000	
Implementation				$11,736,400	
Channels	793	Acre	$6,000	$4,758,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	1586	Acre	$4,400	$6,978,400	$4,400 per acre
Operation & Maintenance	16.0	Year	$500,000	$8,000,000	
D. Dredging, Transportation & Placement Costs				**$347,975,000**	
Mob and Demob	16.0	Year	$2,000,000	$32,000,000	Mob & Demob for operating life of site
Dredging	38.3	Mcy	$2.00	$76,600,000	Clamshell Dredging
Transport	38.3	Mcy	$4.00	$153,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	38.3	Mcy	$2.25	$86,175,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$521,885,379**	
Contingency	15.00%			$78,282,807	
TOTAL COST A+B+C+D				**$600,168,186**	
TOTAL UNIT COST				**$15.67**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-10 - Total site use cost analysis for Dike Alignment No. 3 - (10 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	38.3	Site Surface Area (Ac)	1,586
Site Operating Life (Years)	16	Site Perimeter Dike (Ft)	44,497
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	17,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	38.3	MCY	$1.60	$61,122,023	
Initial Construction Costs				$58,122,023	Refer to Table 8, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			$4,463,715	$77,629,170	
Dredged Material Management	16.0	Year	$1,696,350	$27,141,600	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	18.0	Year	$2,092,365	$37,662,570	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	19.0	Year	$675,000	$12,825,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				$30,736,400	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	16.0	Year	$500,000	$8,000,000	
Implementation				$11,736,400	
Channels	793	Acre	$6,000	$4,758,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	1586	Acre	$4,400	$6,978,400	$4,400 per acre
Operation & Maintenance	16.0	Year	$500,000	$8,000,000	
D. Dredging, Transportation & Placement Costs				$347,975,000	
Mob and Demob	16.0	Year	$2,000,000	$32,000,000	Mob & Demob for operating life of site
Dredging	38.3	Mcy	$2.00	$76,600,000	Clamshell Dredging
Transport	38.3	Mcy	$4.00	$153,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	38.3	Mcy	$2.25	$86,175,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				$517,462,593	
Contingency	15.00%			$77,619,389	
TOTAL COST A+B+C+D				$595,081,982	
TOTAL UNIT COST				$15.54	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-11 - Total site use cost analysis for Dike Alignment No. 3 - (20 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	58.0	Site Surface Area (Ac)	1,586
Site Operating Life (Years)	24	Site Perimeter Dike (Ft)	44,497
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	17,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**58.0**	**MCY**	**$1.40**	**$80,931,949**	
Initial Construction Costs				$77,931,949	Refer to Table 8, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$4,463,715**	**$113,338,890**	
Dredged Material Management	24.0	Year	$1,696,350	$40,712,400	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	26.0	Year	$2,092,365	$54,401,490	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	27.0	Year	$675,000	$18,225,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$38,736,400**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	24.0	Year	$500,000	$12,000,000	
Implementation				$11,736,400	
Channels	793	Acre	$6,000	$4,758,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	1586	Acre	$4,400	$6,978,400	$4,400 per acre
Operation & Maintenance	24.0	Year	$500,000	$12,000,000	
D. Dredging, Transportation & Placement Costs				**$526,500,000**	
Mob and Demob	24.0	Year	$2,000,000	$48,000,000	Mob & Demob for operating life of site
Dredging	58.0	Mcy	$2.00	$116,000,000	Clamshell Dredging
Transport	58.0	Mcy	$4.00	$232,000,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	58.0	Mcy	$2.25	$130,500,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$759,507,239**	
Contingency	15.00%			$113,926,086	
TOTAL COST A+B+C+D				**$873,433,325**	
TOTAL UNIT COST				**$15.06**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-12 - Total site use cost analysis for Dike Alignment No. 3 - (20 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	58.0	Site Surface Area (Ac)	1,586
Site Operating Life (Years)	24	Site Perimeter Dike (Ft)	44,497
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	17,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**58.0**	**MCY**	**$1.27**	**$73,431,735**	
Initial Construction Costs				$70,431,735	Refer to Table 8, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$4,463,715**	**$113,338,890**	
Dredged Material Management	24.0	Year	$1,696,350	$40,712,400	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	26.0	Year	$2,092,365	$54,401,490	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	27.0	Year	$675,000	$18,225,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$38,736,400**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	24.0	Year	$500,000	$12,000,000	
Implementation				$11,736,400	
Channels	793	Acre	$6,000	$4,758,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	1586	Acre	$4,400	$6,978,400	$4,400 per acre
Operation & Maintenance	24.0	Year	$500,000	$12,000,000	
D. Dredging, Transportation & Placement Costs				**$526,500,000**	
Mob and Demob	24.0	Year	$2,000,000	$48,000,000	Mob & Demob for operating life of site
Dredging	58.0	Mcy	$2.00	$116,000,000	Clamshell Dredging
Transport	58.0	Mcy	$4.00	$232,000,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	58.0	Mcy	$2.25	$130,500,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$752,007,025**	
Contingency	15.00%			$112,801,054	
TOTAL COST A+B+C+D				**$864,808,079**	
TOTAL UNIT COST				**$14.91**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-13 - Total site use cost analysis for Dike Alignment No. 4 - (10 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	54.3	Site Surface Area (Ac)	2,200
Site Operating Life (Years)	22	Site Perimeter Dike (Ft)	48,963
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	19,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**54.3**	**MCY**	**$1.36**	**$73,697,279**	
Initial Construction Costs				$70,697,279	Refer to Table 9, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$5,263,335**	**$122,405,040**	
Dredged Material Management	22.0	Year	$2,295,000	$50,490,000	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	24.0	Year	$2,293,335	$55,040,040	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	25.0	Year	$675,000	$16,875,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$41,280,000**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	22.0	Year	$500,000	$11,000,000	
Implementation				$16,280,000	
Channels	1100	Acre	$6,000	$6,600,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2200	Acre	$4,400	$9,680,000	$4,400 per acre
Operation & Maintenance	22.0	Year	$500,000	$11,000,000	
D. Dredging, Transportation & Placement Costs				**$491,975,000**	
Mob and Demob	22.0	Year	$2,000,000	$44,000,000	Mob & Demob for operating life of site
Dredging	54.3	Mcy	$2.00	$108,600,000	Clamshell Dredging
Transport	54.3	Mcy	$4.00	$217,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	54.3	Mcy	$2.25	$122,175,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$729,357,319**	
Contingency	15.00%			$109,403,598	
TOTAL COST A+B+C+D				**$838,760,917**	
TOTAL UNIT COST				**$15.45**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-14 - Total site use cost analysis for Dike Alignment No. 4 - (10 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	54.3	Site Surface Area (Ac)	2,200
Site Operating Life (Years)	22	Site Perimeter Dike (Ft)	48,963
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	19,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**54.3**	**MCY**	**$1.27**	**$68,815,047**	
Initial Construction Costs				$65,815,047	Refer to Table 9, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibiliy and feasibility costs.
B. Site Development Costs			**$5,263,335**	**$122,405,040**	
Dredged Material Management	22.0	Year	$2,295,000	$50,490,000	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	24.0	Year	$2,293,335	$55,040,040	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	25.0	Year	$675,000	$16,875,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$41,280,000**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	22.0	Year	$500,000	$11,000,000	
Implementation				$16,280,000	
Channels	1100	Acre	$6,000	$6,600,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2200	Acre	$4,400	$9,680,000	$4,400 per acre
Operation & Maintenance	22.0	Year	$500,000	$11,000,000	
D. Dredging, Transportation & Placement Costs				**$491,975,000**	
Mob and Demob	22.0	Year	$2,000,000	$44,000,000	Mob & Demob for operating life of site
Dredging	54.3	Mcy	$2.00	$108,600,000	Clamshell Dredging
Transport	54.3	Mcy	$4.00	$217,200,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	54.3	Mcy	$2.25	$122,175,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$724,475,087**	
Contingency	15.00%			$108,671,263	
TOTAL COST A+B+C+D				**$833,146,350**	
TOTAL UNIT COST				**$15.34**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-15 - Total site use cost analysis for Dike Alignment No. 4 - (20 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	81.6	Site Surface Area (Ac)	2,200
Site Operating Life (Years)	33	Site Perimeter Dike (Ft)	48,963
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	19,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**81.6**	**MCY**	**$1.11**	**$90,362,835**	
Initial Construction Costs				$87,362,835	Refer to Table 9, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$5,263,335**	**$180,301,725**	
Dredged Material Management	33.0	Year	$2,295,000	$75,735,000	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	35.0	Year	$2,293,335	$80,266,725	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	36.0	Year	$675,000	$24,300,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$52,280,000**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	33.0	Year	$500,000	$16,500,000	
Implementation				$16,280,000	
Channels	1100	Acre	$6,000	$6,600,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2200	Acre	$4,400	$9,680,000	$4,400 per acre
Operation & Maintenance	33.0	Year	$500,000	$16,500,000	
D. Dredging, Transportation & Placement Costs				**$739,200,000**	
Mob and Demob	33.0	Year	$2,000,000	$66,000,000	Mob & Demob for operating life of site
Dredging	81.6	Mcy	$2.00	$163,200,000	Clamshell Dredging
Transport	81.6	Mcy	$4.00	$326,400,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	81.6	Mcy	$2.25	$183,600,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$1,062,144,560**	
Contingency	15.00%			$159,321,684	
TOTAL COST A+B+C+D				**$1,221,466,244**	
TOTAL UNIT COST				**$14.97**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-16 - Total site use cost analysis for Dike Alignment No. 4 - (20 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	81.6	Site Surface Area (Ac)	2,200
Site Operating Life (Years)	33	Site Perimeter Dike (Ft)	48,963
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	19,628
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**81.6**	**MCY**	**$1.00**	**$81,926,322**	
Initial Construction Costs				$78,926,322	Refer to Table 9, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$5,263,335**	**$180,301,725**	
Dredged Material Management	33.0	Year	$2,295,000	$75,735,000	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	35.0	Year	$2,293,335	$80,266,725	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	36.0	Year	$675,000	$24,300,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$52,280,000**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	33.0	Year	$500,000	$16,500,000	
Implementation				$16,280,000	
Channels	1100	Acre	$6,000	$6,600,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2200	Acre	$4,400	$9,680,000	$4,400 per acre
Operation & Maintenance	33.0	Year	$500,000	$16,500,000	
D. Dredging, Transportation & Placement Costs				**$739,200,000**	
Mob and Demob	33.0	Year	$2,000,000	$66,000,000	Mob & Demob for operating life of site
Dredging	81.6	Mcy	$2.00	$163,200,000	Clamshell Dredging
Transport	81.6	Mcy	$4.00	$326,400,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	81.6	Mcy	$2.25	$183,600,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$1,053,708,047**	
Contingency	15.00%			$158,056,207	
TOTAL COST A+B+C+D				**$1,211,764,254**	
TOTAL UNIT COST				**$14.85**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-17 - Total site use cost analysis for Dike Alignment No. 5 - (10 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	51.2	Site Surface Area (Ac)	2,072
Site Operating Life (Years)	21	Site Perimeter Dike (Ft)	45,587
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,530
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**51.2**	**MCY**	**$1.43**	**$73,176,243**	
Initial Construction Costs				$70,176,243	Refer to Table 10, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$4,986,615**	**$111,026,745**	
Dredged Material Management	21.0	Year	$2,170,200	$45,574,200	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	23.0	Year	$2,141,415	$49,252,545	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	24.0	Year	$675,000	$16,200,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$39,332,800**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	21.0	Year	$500,000	$10,500,000	
Implementation				$15,332,800	
Channels	1036	Acre	$6,000	$6,216,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2072	Acre	$4,400	$9,116,800	$4,400 per acre
Operation & Maintenance	21.0	Year	$500,000	$10,500,000	
D. Dredging, Transportation & Placement Costs				**$464,400,000**	
Mob and Demob	21.0	Year	$2,000,000	$42,000,000	Mob & Demob for operating life of site
Dredging	51.2	Mcy	$2.00	$102,400,000	Clamshell Dredging
Transport	51.2	Mcy	$4.00	$204,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	51.2	Mcy	$2.25	$115,200,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$687,935,788**	
Contingency	15.00%			$103,190,368	
TOTAL COST A+B+C+D				**$791,126,156**	
TOTAL UNIT COST				**$15.45**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-18 - Total site use cost analysis for Dike Alignment No. 5 - (10 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	51.2	Site Surface Area (Ac)	2,072
Site Operating Life (Years)	21	Site Perimeter Dike (Ft)	45,587
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,530
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**51.2**	**MCY**	**$1.33**	**$68,294,010**	
Initial Construction Costs				$65,294,010	Refer to Table 10, Borrow Altemative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$4,986,615**	**$111,026,745**	
Dredged Material Management	21.0	Year	$2,170,200	$45,574,200	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	23.0	Year	$2,141,415	$49,252,545	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	24.0	Year	$675,000	$16,200,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$39,332,800**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	21.0	Year	$500,000	$10,500,000	
Implementation				$15,332,800	
Channels	1036	Acre	$6,000	$6,216,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2072	Acre	$4,400	$9,116,800	$4,400 per acre
Operation & Maintenance	21.0	Year	$500,000	$10,500,000	
D. Dredging, Transportation & Placement Costs				**$464,400,000**	
Mob and Demob	21.0	Year	$2,000,000	$42,000,000	Mob & Demob for operating life of site
Dredging	51.2	Mcy	$2.00	$102,400,000	Clamshell Dredging
Transport	51.2	Mcy	$4.00	$204,800,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	51.2	Mcy	$2.25	$115,200,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$683,053,555**	
Contingency	15.00%			$102,458,033	
TOTAL COST A+B+C+D				**$785,511,588**	
TOTAL UNIT COST				**$15.34**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-19 - Total site use cost analysis for Dike Alignment No. 5 - (20 FT) - Borrow Alternative No. 3*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	76.9	Site Surface Area (Ac)	2,072
Site Operating Life (Years)	31	Site Perimeter Dike (Ft)	45,587
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,530
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**76.9**	**MCY**	**$1.17**	**$89,790,788**	
Initial Construction Costs				$86,790,788	Refer to Table 10, Borrow Alternative 3 (offsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$4,986,615**	**$160,892,895**	
Dredged Material Management	31.0	Year	$2,170,200	$67,276,200	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	33.0	Year	$2,141,415	$70,666,695	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	34.0	Year	$675,000	$22,950,000	Environmental monitoring for operating life
					plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$49,332,800**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	31.0	Year	$500,000	$15,500,000	
Implementation				$15,332,800	
Channels	1036	Acre	$6,000	$6,216,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2072	Acre	$4,400	$9,116,800	$4,400 per acre
Operation & Maintenance	31.0	Year	$500,000	$15,500,000	
D. Dredging, Transportation & Placement Costs				**$696,425,000**	
Mob and Demob	31.0	Year	$2,000,000	$62,000,000	Mob & Demob for operating life of site
Dredging	76.9	Mcy	$2.00	$153,800,000	Clamshell Dredging
Transport	76.9	Mcy	$4.00	$307,600,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	76.9	Mcy	$2.25	$173,025,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$996,441,483**	
Contingency	15.00%			$149,466,222	
TOTAL COST A+B+C+D				**$1,145,907,705**	
TOTAL UNIT COST				**$14.90**	**per cubic yard**

* Costs are estimated in 2001 dollars.

JAMES ISLAND HABITAT DEVELOPMENT

Table B-20 - Total site use cost analysis for Dike Alignment No. 5 - (20 FT) - Borrow Alternative No. 4*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	76.9	Site Surface Area (Ac)	2,072
Site Operating Life (Years)	31	Site Perimeter Dike (Ft)	45,587
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	18,530
Average One-Way Haul Distance (NM)	40	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs	**76.9**	**MCY**	**$1.06**	**$81,354,275**	
Initial Construction Costs				$78,354,275	Refer to Table 10, Borrow Alternative 4 (Onsite)
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs			**$4,986,615**	**$160,892,895**	
Dredged Material Management	31.0	Year	$2,170,200	$67,276,200	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	33.0	Year	$2,141,415	$70,666,695	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	34.0	Year	$675,000	$22,950,000	Environmental monitoring for operating life plus 3 years following site placement.
C. Site Finishing Cost (Habitat Development)				**$49,332,800**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	31.0	Year	$500,000	$15,500,000	
Implementation				$15,332,800	
Channels	1036	Acre	$6,000	$6,216,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2072	Acre	$4,400	$9,116,800	$4,400 per acre
Operation & Maintenance	31.0	Year	$500,000	$15,500,000	
D. Dredging, Transportation & Placement Costs				**$696,425,000**	
Mob and Demob	31.0	Year	$2,000,000	$62,000,000	Mob & Demob for operating life of site
Dredging	76.9	Mcy	$2.00	$153,800,000	Clamshell Dredging
Transport	76.9	Mcy	$4.00	$307,600,000	$0.10 Per One-Way Haul in NM (40 NM)
Placement	76.9	Mcy	$2.25	$173,025,000	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$988,004,970**	
Contingency	15.00%			$148,200,746	
TOTAL COST A+B+C+D				**$1,136,205,716**	
TOTAL UNIT COST				**$14.78**	**per cubic yard**

* Costs are estimated in 2001 dollars.

APPENDIX F

Appendix F:

James Island Habitat Restoration Existing Environmental Conditions: Fall 2001 and Summer 2002 Surveys

(EA Engineering, Science, and Technology, Inc.)

FINAL

JAMES ISLAND HABITAT RESTORATION EXISTING ENVIRONMENTAL CONDITIONS:

Fall 2001 and Summer 2002 Surveys

Prepared for

Maryland Port Administration
2310 Broening Highway
Baltimore, MD 21224

Prepared Under Contract to

Maryland Environmental Service
2011 Commerce Park Drive
Annapolis, MD 21401

Prepared by

EA Engineering, Science & Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

MES Contract # 03-07-11
MPA Contract # 500912
MPA Pin # 600105-P
Project # 02-07-09

February 2003

EXECUTIVE SUMMARY

James Island and the waters surrounding it were investigated over two seasons. The purpose of the sampling efforts was to document the existing terrestrial and aquatic resources present in and around the James Island remnants. This report documents the site reconnaissance efforts of Fall 2001 and the first season of sampling for feasibility-level evaluations (Summer 2002). Components of the investigation are detailed in Table ES-1.

TABLE ES-1. COMPONENTS OF SITE RECONNAISSANCE AND SAMPLING EFFORTS BY SEASON AT JAMES ISLAND

Season of Sampling	Type of Study Conducted
Fall 2001	– Benthic Community – *In Situ* Water Quality – Sediment Quality – Wildlife and Avian Observations
Summer 2002	– Benthic Community – *In Situ* Water Quality – Fisheries Studies (trawl & seine collections) – Plankton Collections – Wildlife and Avian Observations – Timed Bird Observations – Submerged Aquatic Vegetation (SAV) Mapping and Field Ground-Truthing

These data will support reconnaissance and feasibility-level studies of James Island (Dorchester County, Maryland) as a potential island habitat restoration project using dredged material. This study was conducted by EA Engineering, Science, and Technology, Inc. (EA) for the Maryland Port Administration (MPA) under contract to Maryland Environmental Service (MES).

James Island currently consists of three eroding island remnants. The northern two remnants are joined by a sand beach/spit that terminates in high and low marsh complexes. Mixed forest stands of loblolly pine dominate the interior of the islands. Small remnants of high marsh can be found on all three remnants and the southern remnant has a fairly extensive marsh complex in the center. There was evidence of a fairly recent fire that killed many trees and impacted some of the marsh areas on the northern and southern remnants. The northern and western shorelines of each remnant show the heaviest erosion and there are many downed trees in the water in these areas.

Avian utilization of the island was typical for this area of the Bay, although numbers of species for Summer 2002 were low relative to expectations since the survey may have missed the period of abundance during the Spring migration. No large bird colonies (e.g., gulls, egrets, pelican, etc.) were found on the island. The island provides nesting habitat for a variety of songbirds and raptors. A total of 42 avian species were observed utilizing it in some capacity, during the Fall

2001 and Summer 2002 surveys. There was also evidence that common wildlife species such as sika deer, raccoon, diamondback terrapin, and several snake species also utilize the island remnants.

The island remnants currently support submerged aquatic vegetation (SAV) growth along their eastern shorelines. It is primarily a monotypic bed of widgeon grass (*Ruppia maritima*) with some small pockets of the macroalgae, sea lettuce (*Ulva lactuca*). Fisheries investigations of the shorelines indicated that the remnants support a fairly diverse fish community, including juveniles of commercially important species. All species were typical of the region. There were no differences in the number of fish species collected inside and outside of the SAV beds in Summer 2002. Trawling yielded few species. This is likely due to a lack of habitat features outside of the shorezone of the island and because of this, most fish utilizing the area trawled are probably transients to the study area.

Ichthyoplantkton densities were relatively high for the Summer 2002 collection effort and were dominated by the bay anchovy. Zooplankton were typical of the region. In general, the benthic community is typical of this area of the Bay but was dominated by a single species, the gem clam (*Gemma gemma*), at most stations. The majority of the species collected were stress-tolerant, resulting in low Benthic Index of Biotic Integrity (B-IBI) scores at most locations in both Fall 2001 and Summer 2002. Although the *in situ* water quality was typical for the region, lower than normal precipitation could have affected benthic distributions in the area in Summer 2002.

Results of the physical analyses indicated that the sediment around James Island was predominately comprised of sand (97.5 to 98.8%) at all sample stations except JAM-010, which was predominately comprised of silt-clay (82.8%). Of the five James Island sediment samples, location JAM-007 had the highest proportion of sand (98.9%), although both stations JAM-002 and JAM-005 also had high proportions of sand (98.4%).

Of the 155 chemical constituents tested in the sediment, 57 were detected in the James Island sediments. The majority of these detected constituents were found in low concentrations and were representative of background concentrations. Semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), and organophosphorus pesticides were not detected in any of the sediment samples. One polynuclear aromatic hydrocarbon (PAH), acenaphthylene, exceeded the threshold effects level (TEL) value at one sampling station (JAM-002) by a factor of approximately 2.6 but did not exceed probable effects level (PEL) values. None of the other detected chemical constituents exceeded TEL values.

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1.0 INTRODUCTION

1.1 PURPOSE OF STUDY

The purpose of the James Island environmental sampling effort is to document the existing terrestrial and aquatic resources present in and around the James Island remnants. This report documents the site reconnaissance efforts of Fall 2001 and a season of sampling (Summer 2002) to support feasibility-level evaluations. Components of the investigation are included in Table 1-1 below.

TABLE 1-1. COMPONENTS OF SITE RECONNAISSANCE AND SAMPLING EFFORTS BY SEASON AT JAMES ISLAND

Season of Sampling	Type of Study Conducted
Fall 2001	– Benthic Community – *In Situ* Water Quality – Sediment Quality – Wildlife and avian observations
Summer 2002	– Benthic Community – *In Situ* Water Quality – Fisheries Studies (trawl & seine collections) – Plankton Collections – Wildlife and Avian Observations – Timed bird observations – Submerged Aquatic Vegetation (SAV) Mapping and Field Ground-Truthing

These data will support reconnaissance and feasibility-level studies of James Island (Dorchester County, Maryland) as a potential island habitat restoration project using dredged material.

This study was conducted by EA Engineering, Science, and Technology, Inc. (EA) for the Maryland Port Administration (MPA), under contract to Maryland Environmental Service (MES).

1.2 STUDY AREA DESCRIPTION

James Island is located in Dorchester County (Maryland) at the mouth of the Little Choptank River in the Chesapeake Bay (Figure 1-1). Historic and current mapping of the island indicated that over 800 acres of the island has eroded since 1847. James Island currently consists of three remnants and is less than 100 acres in size. It lies approximately one mile north-northwest of Taylor Island. James Island is currently being considered for an island restoration project. Five potential dike alignments are being considered at this phase of study (Figure 1-2). The alignments include a 50/50 upland to wetland ratio using 40 to 80 million cubic yards (mcy) of suitable dredged material. The alignments range in size from 979 to 2,202 acres and all lie predominantly west of the remnants of James Island.

Sampling was conducted within and adjacent to the alignments of the proposed project and on and around the three island remnants (northern, middle, and southern remnants). Details of sampling and observation areas are included with the methods for each discipline (Section 2), and a photographic record of the terrestrial resources documented on James Island during the Fall 2001 and Summer 2002 surveys is included as Appendix A.

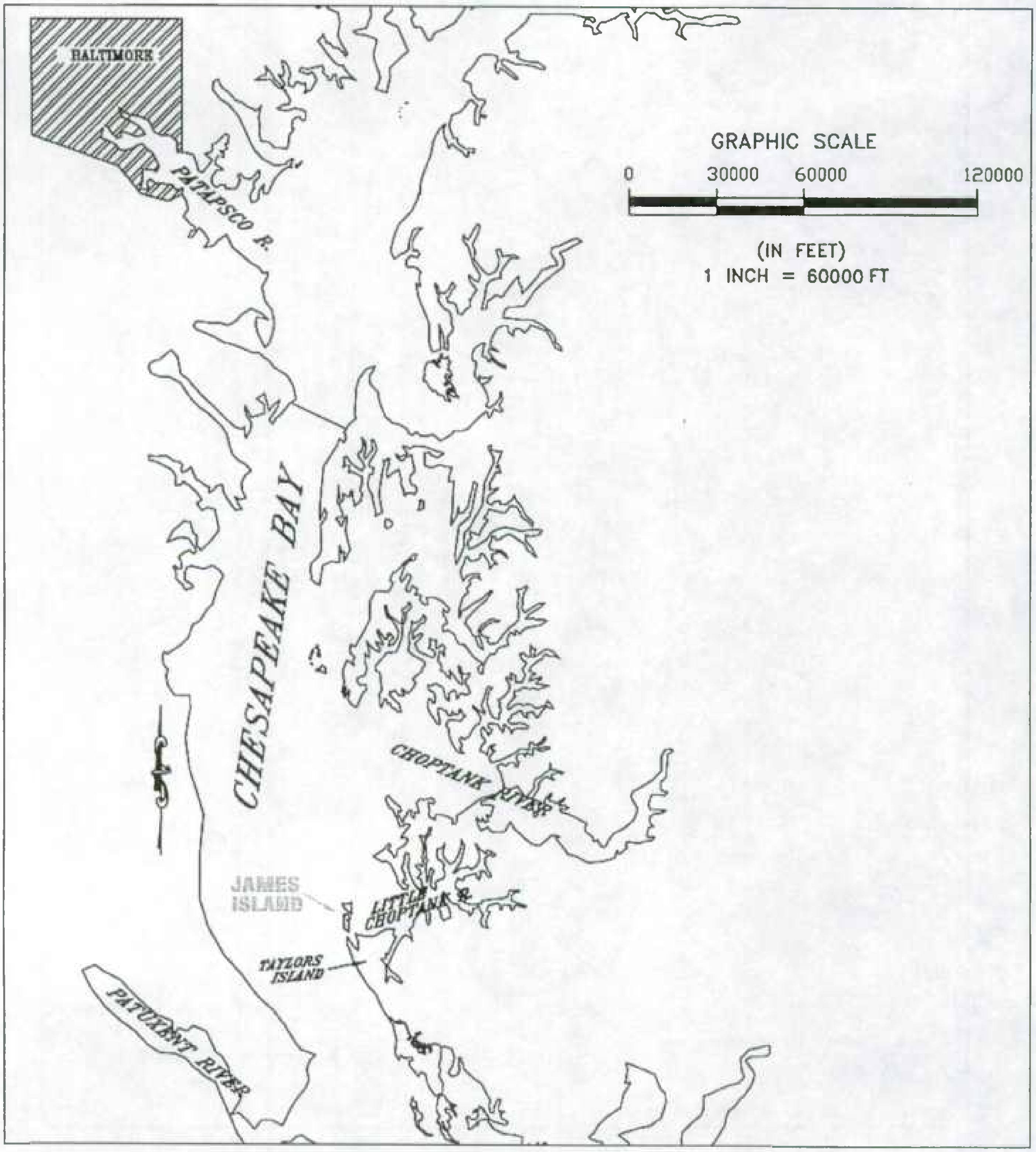


Figure 1-1. Location of James Island, Dorchester County, MD

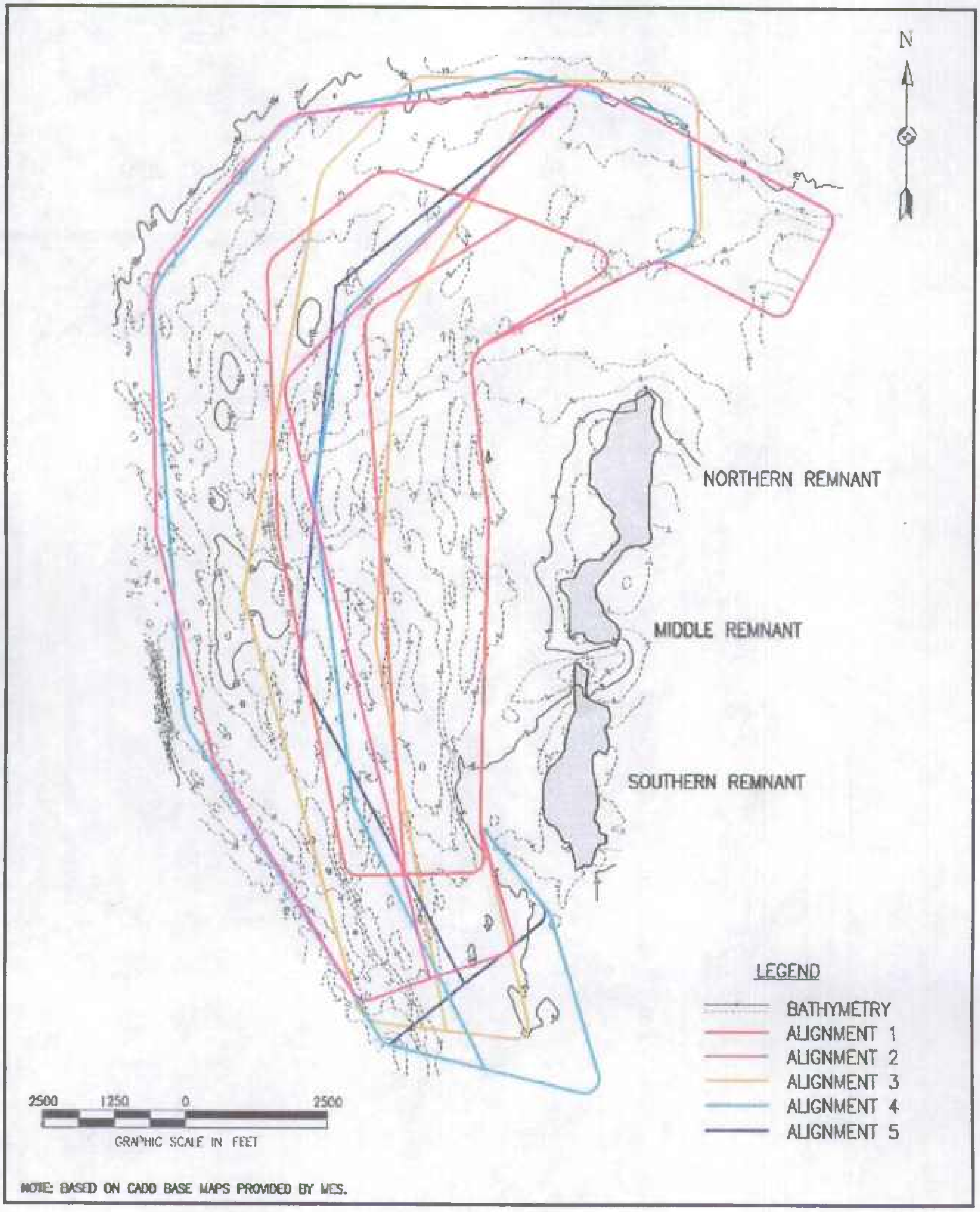


Figure 1-2. Proposed Placement Areas at James Island

2.0 METHODS

2.1 AQUATIC SURVEYS

2.1.1 Benthic Community

Benthic sampling was conducted in the Fall (October) 2001 and Summer (June) 2002 seasons.

Sampling Methods

Triplicate grab samples were collected at 10 locations around James Island (Figure 2-1) using a standard 9-in. × 9-in. Ponar grab sampler. Differential global positioning system (DGPS) coordinates were recorded at each of the ten benthic sampling stations and are included in Appendix B. One additional grab was collected at five locations for analysis of grain size and total organic carbon (TOC). Each replicate benthic sample was sieved in the field through a 500-micron screen to remove fine sediment particles. Individual replicates were transferred to labeled bottles and preserved in the field using buffered 10 percent formaldehyde solution stained with rose bengal.

Sediment Sampling for Grain Size and Total Organic Carbon (TOC)

Separate sediment samples were collected for grain size and TOC analysis from five benthic stations (JAM-002, JAM-005, JAM-007, JAM-009, and JAM-010). The sediment samples were stored in certified clean containers and refrigerated at 4°C during storage. Samples were obtained using a standard 9-in. × 9-in. Ponar grab sampler. Samples were transported to Severn-Trent Laboratories–Baltimore (STL–Baltimore) in Sparks, Maryland for physical testing of the sediment for grain size distribution and TOC analysis. Grain size analyses were conducted according to American Society for Testing and Materials (ASTM) standard methods (ASTM 1995). TOC analyses were conducted according to American Public Health Association (APHA) guidelines (APHA 1992). In addition, the substrate was characterized visually at each sampling station.

In Situ Water Quality Measurements

In situ water quality measurements were obtained in the field at mid-depth at the benthic infaunal sampling locations using YSI 3800 instrumentation. The *in situ* water quality measurements included temperature, pH, salinity, dissolved oxygen, and turbidity.

Sample Storage and Transport

Benthic samples collected over a two-day work period were preserved in a buffered 10 percent formaldehyde solution in the field and stored in appropriate containers out of direct sunlight on the work boat. Grain size and TOC samples were stored on ice in cooled, insulated containers at 4°C on the work boat. After completion of benthic sampling, the samples were transported to EA in Sparks, Maryland, where they were logged and stored until laboratory processing.

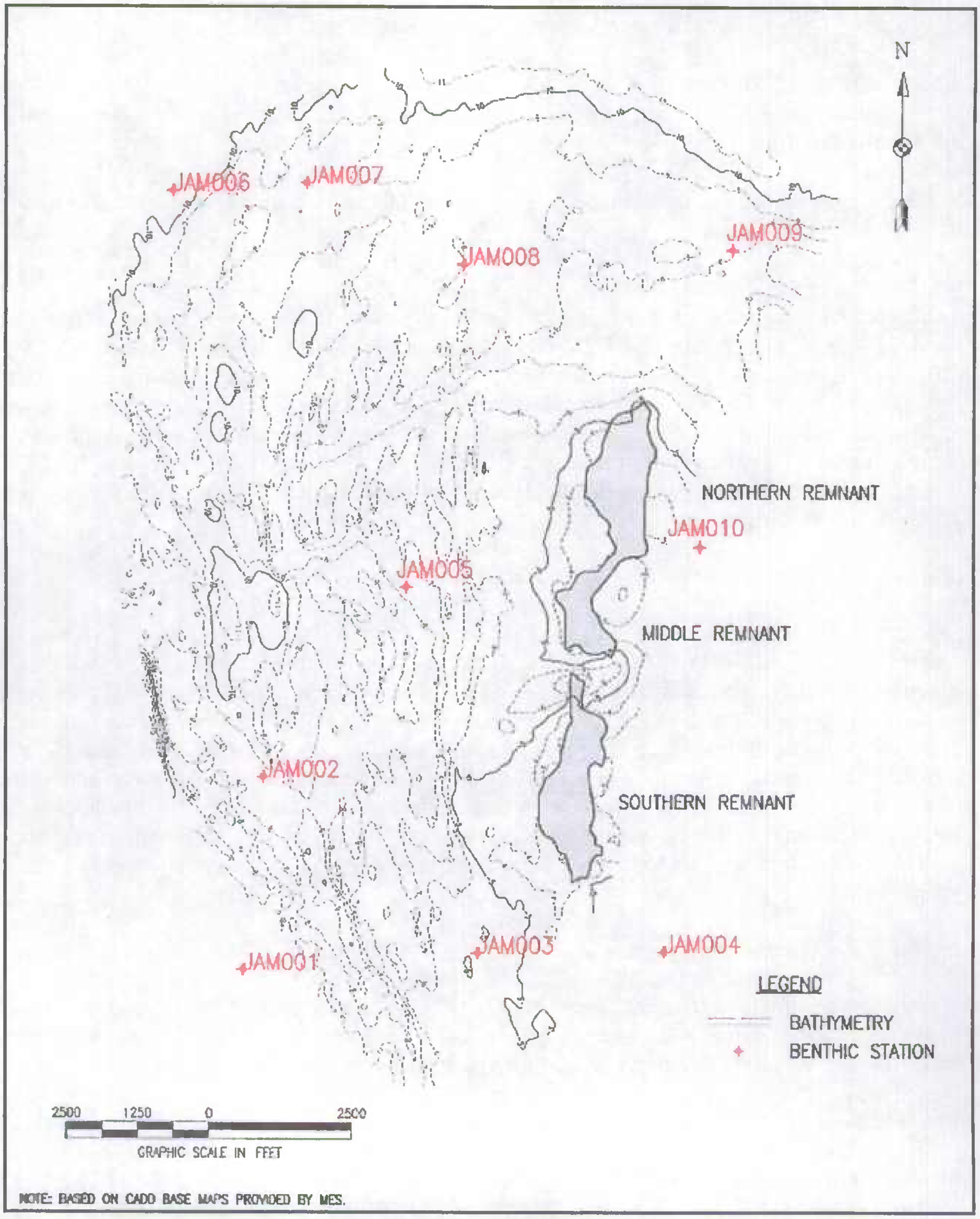


Figure 2-1. Benthic Stations in Vicinity of James Island, October 2001 and June 2002

Samples were sorted and sub-sampled in EA's Biology Laboratory, and sent to Cove Corporation for taxonomic identification to the lowest practical taxonomic level. Grain size and TOC samples were transported to EA in Sparks, Maryland, logged and stored in a refrigeration unit (maintained at 4°C) until delivered to STL–Baltimore for processing and analysis. Before the samples were sent to the laboratories, appropriate chain-of-custody (COC) documentation was completed.

Laboratory Processing

In the laboratory, each benthic infaunal sample was washed with tap water through a 0.5-mm sieve to remove the preservative in preparation for lab processing. Due to the large number of organisms in the samples, the samples were sub-sampled. The sub-samples were placed in a shallow white pan and the organisms were separated from other sample material and placed in vials. The samples were sorted by major taxonomic groups and were submitted to Cove Corporation for identification to the lowest practical taxonomic level.

Data Analysis for the Benthic Index of Biotic Integrity (B-IBI)

Benthic invertebrates are used extensively as indicators of estuarine environmental status and trends because numerous studies have demonstrated that benthos respond predictably to many kinds of natural and anthropogenic stress (Weisberg et al. 1997). The Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI) developed by Weisberg et al. (1997) was used to evaluate the benthic community. The metrics were designed to characterize the response of the benthic community to stresses. The B-IBI combines individual metrics and assigns a score to each of the metrics to describe the benthic community and to provide an assessment of benthic community condition. Methodology followed guidance provided in both Weisberg et al. (1997) and Interstate Commission on the Potomac River Basin (ICPRB 1999).

In order to calculate the B-IBI, each station must be classified by salinity and substrate type. Salinity at the James Island benthic stations in both October 2001 and June 2002 ranged from 12 to 18 parts per thousand (ppt), classifying the stations as high mesohaline (Weisberg et al. 1997). All benthic stations (except JAM-004 and JAM-010) had a silt/clay content of less than 40 percent and would be classified as sand habitat. JAM-004 had a silt/clay content of 90 percent and JAM-010 had a silt/clay content of 82.8 percent, which would classify them as mud. According to the ICPRB, substrate habitat is defined as sand if the average silt/clay value is between 0 and 40 percent and as mud if it is greater than 40 percent (ICPRB 1999). Therefore, all of the James Island benthic infaunal stations were classified as high mesohaline sand, except for JAM-004 and JAM-010, which were classified as high mesohaline mud. The metrics included in the B-IBI for the high mesohaline sand and high mesohaline mud classification are as follows:

- Shannon-Weiner Diversity Index $\overline{H}$ – This index has probably been the most widely used index in community ecology. It is based on information theory and is a measure of the average degree of "uncertainty" in predicting the species of an individual chosen at random from a collection of *S* species and *N* individuals (Weisberg et al. 1997). This metric is influenced by species richness and the distribution of individuals among the species (Weber 1973). This metric is included in both the high mesohaline sand and high mesohaline mud classification for the B-IBI. The Shannon-Weiner Diversity Index is calculated using the following equation:

$$\overline{H} = -\sum \left(\frac{ni}{N}\right) \log_e \left(\frac{ni}{N}\right)$$

where:

ni = importance[(a)] value for each species
N = Total of importance values

(a) Importance = number of individuals of a given species

- Abundance – Total abundance was calculated as total number of organisms per square meter. This metric is included in both the high mesohaline sand and high mesohaline mud classification for the B-IBI.

- Stress-Indicative Taxa Abundance – This metric was calculated as the percentage of total abundance represented by stress-indicative taxa. This metric is included only in the high mesohaline sand classification for the B-IBI.

- Stress-Sensitive Taxa Abundance – This metric was calculated as the percentage of total abundance represented by stress-sensitive taxa. This metric is included only in the high mesohaline sand classification for the B-IBI.

- Carnivore/Omnivore Abundance – This metric was calculated as the percentage of total abundance represented by carnivore/omnivore taxa. This metric is included in both the high mesohaline sand and high mesohaline mud classification for the B-IBI.

Table 2-1 presents the metrics and the thresholds used to score each metric of the B-IBI. The Index of Biotic Integrity (IBI) approach involves scoring each metric as 5, 3, or 1, depending on whether its value at a site approximates, deviates slightly, or deviates greatly from conditions at reference sites (Weisberg et al. 1997). The final IBI score is derived by summing individual scores for each metric and calculating an average score (IBI value). The B-IBI is an extension of an effort to establish benthic restoration goals for the Chesapeake Bay (Weisberg et al. 1997). The Chesapeake Bay Restoration Goal Index (RGI) (Ranasinghe et al. 1994) was patterned after the same approach used to develop the IBI for freshwater systems (Karr et al. 1986). A Chesapeake Bay RGI value of 3 represents the minimum restoration goal. RGI values of less than 3 are indicative of a stressed community. Values of three or more indicate habitats that meet or exceed the restoration goals (Ranasinghe et al. 1994).

In order to calculate the B-IBI, feeding guilds and life histories of the benthic fauna were assigned to each species. Feeding guilds were derived from the ICPRB and life histories were derived from Weisberg (Weisberg et al. 1997). A summary of the feeding guilds and life histories of the benthic fauna collected at James Island is presented in Table 2-2.

TABLE 2-1. THRESHOLD VALUES FOR METRICS USED TO SCORE THE CHESAPEAKE BAY B-IBI AT JAMES ISLAND FOR HIGH MESOHALINE SAND AND MUD

Metric	**Scoring Criteria for High Mesohaline Sand**		
	5 (Exceeds RGI)	**3 (Meets RGI)**	**1 (Below RGI-Stressed)**
Shannon-Weiner Diversity[a]	≥2.2	1.7-2.2	<1.7
Abundance (#/m^2)	≥1500-3000	1000-1500 or ≥3000-5000	<1000 or ≥5000
Stress-Indicative Taxa Abundance (%)	≤10	10-25	>25
Stress-Sensitive Taxa Abundance (%)	≥40	10-40	<10
Carnivore/Omnivore Abundance (%)	≥35	20-35	<20
Metric	**Scoring Criteria for High Mesohaline Mud**		
	5 (Exceeds RGI)	**3 (Meets RGI)**	**1 (Below RGI-Stressed)**
Shannon-Weiner Diversity[a]	≥2.1	1.4-2.1	<1.4
Abundance (#/m^2)	≥1500-2500	1000-1500 or ≥2500-5000	<1000 or ≥5000
Carnivore/Omnivore Abundance (%)	≥25	10-25	<10

[a] Converted to log base e

Source: Weisberg et al. 1997 and ICPRB 1999

TABLE 2-2. FEEDING GUILD AND LIFE HISTORY INFORMATION FOR BENTHIC MACROINVERTEBRATES COLLECTED FROM JAMES ISLAND, OCTOBER 2001 AND JUNE 2002

Taxa	Feeding Guild[a]	Life History[b]
CNIDARIA (sea anemones)		
Edwardsia elegans	Carnivore/omnivore	--
PLATYHELMINTHES (flatworms)		
Stylochus ellipticus[e]	Not assigned	--
Planariidae[e]	Not assigned	--
Turbellaria sp.A[e]	Not assigned	--
NEMERTINEA (unsegmented worms)	Carnivore/omnivore	--
Amphiporidae sp.	Not assigned	--
Amphiporus bioculatus	Not assigned	--
Micrura leidyi	Carnivore/omnivore	--
Carinoma tremaphorus	Carnivore/omnivore	--
GASTROPODA (snails)		
Acteocina canaliculata	Carnivore/omnivore	--
Sayella chesapeakea	Carnivore/omnivore	--
Haminoea solitaria	Carnivore/omnivore	--
Boonea impressa[e]	Carnivore/omnivore	--
Hydrobia truncata	Carnivore/omnivore	
BIVALVIA (clams and mussels)		
Gemma gemma	Suspension	--
Macoma mitchelli	Interface	--
Macoma balthica	Interface	Stress-sensitive
Mulinia lateralis	Suspension	Stress-sensitive
Mya arenaria	Suspension	Stress-sensitive
Tagelus divisus	Suspension	--
Petricola pholadiformis	Suspension	--
ANNELIDA (segmented worms)		
POLYCHAETA (bristle worms)		
Glycinde solitaria	Carnivore/omnivore	Stress-sensitive
Heteromastus filiformis	Deep deposit	--
Polydora cornuta	Interface	--
Polydora websteri[e]	Interface	--
Paraonis fulgens	Interface	--
Pectinaria gouldii	Deep deposit	--
Neanthes succinea	Carnivore/omnivore	--
Glycera dibranchiata	Carnivore/omnivore	--

(a) Feeding guides taken from Ranasinghe et al. (1993) and the ICPRB (1999).
(b) Life histories taken from Weisberg et al. (1997).
(c) Feeding guild for *Unciola* spp. was used; same family, Corophiidae.
(d) Feeding guild for *Monoculodes* sp. was used; same family, Oedicerotidae.
(e) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999 and Ranasinghe et al. 1993).

TABLE 2-2. (CONTINUED)

Taxa	Feeding Guild[a]	Life History[b]
ANNELIDA (segmented worms)		
POLYCHAETA (bristle worms)		
Eteone heteropoda	Carnivore/omnivore	--
Eteone foliosa	Deep deposit	--
Streblospio benedicti	Interface	Stress-indicative
Marenzellaria viridis	Interface	Stress-sensitive
Mediomastus ambiseta	Deep deposit	Stress-sensitive
Leitoscoloplos spp.	Deep deposit	Stress-indicative
Leitoscoloplos robustus	Deep deposit	Stress-indicative
Podarkeopsis levifuscina	Carnivore/omnivore	--
Paraprionopspio pinnata	Interface	Stress-indicative
Scolelepis (Parascolelepis) Texana	Interface	--
Tharyx sp. A	Interface	--
OLIGOCHAETA (aquatic worms)		
Tubificoides spp.	Deep deposit	Stress-indicative
CRUSTACEA		
AMPHIPODA (beach fleas; scuds)		
Apocorophium lacustre	Interface[c]	--
Ameroculodes spp. Complex	Interface[d]	--
Microprotopus raneyi[e]		
Ampelisca abdita	Suspension	--
Cymadusa compta		
Incisocalliope aestuarius	--	--
Leptocheirus plumulosus	--	Interface
Mucrogammarus mucronatus	--	--
ISOPODA (isopods)		
Edotea triloba[e]		
Cyathura polita	Carnivore/omnivore	Stress-sensitive
Paracereis caudata[e]		
Chiridotea coeca	Carnivore/omnivore	--
CUMACEA (cumacean shrimp)		
Oxyurostylis smithi	Interface	--
BRACHYURA (true crabs)		
Callinectes sapidus	--	--

(a) Feeding guides taken from Ranasinghe et al. (1993) and the ICPRB (1999).
(b) Life histories taken from Weisberg et al. (1997).
(c) Feeding guild for *Unciola* spp. was used; same family, Corophiidae.
(d) Feeding guild for *Monoculodes* sp. was used; same family, Oedicerotidae.
(e) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999 and Ranasinghe et al. 1993).

TABLE 2-2. (CONTINUED)

Taxa	Feeding Guild[a]	Life History[b]
CARIDEA (caridean shrimp)		
Crangon septemspinosa[e]	--	--
BRANCHIURAN (barnacles)		
Balanus improvisus[e]	--	--
MYSIDACEA (mysid shrimp)		
Americamysis almyra[e]	Not assigned	--
Neomysis americana[e]	Not assigned	--
PHORONIDA (horseshoe worms)		
Phoronis sp.	Suspension	--
UROCHORDATA (tunicates)		
Molgula manhattensis[e]	Not assigned	--

(a) Feeding guides taken from Ranasinghe et al. (1993) and the ICPRB (1999).
(b) Life histories taken from Weisberg et al. (1997).
(c) Feeding guild for *Unciola* spp. was used; same family, Corophiidae.
(d) Feeding guild for *Monoculodes* sp. was used; same family, Oedicerotidae.
(e) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999 and Ranasinghe et al. 1993).

Data Analysis for Other Benthic Community Metrics

Four additional metrics were selected to further characterize the benthic community and include total number of taxa, evenness, species richness, and Simpson's dominance index.

- **Total Number of Taxa** is the total number of distinct taxa. This metric reflects the health of the community through a measurement of the variety of taxa present.

- **Evenness (e)** is how the species abundances (e.g., the number of individuals, biomass, etc.) are distributed among the species (Ludwig and Reynolds 1988). Evenness measures the similarities between abundances of different species. When there are similar proportions of all species, evenness is equivalent to one, but when the abundances are very dissimilar (some rare and some common species), the value increases (Geneseo 1996). The equation for Evenness is:

$$e = \frac{\overline{H}}{\log S}$$

where:
$\overline{H}$ = Shannon-Weiner Index value
S = number of species

- **Species richness (d)** is the number of species in the community dependent on the sample size (Ludwig and Reynolds 1988). This index expresses the variety of component of species diversity at each station as a ratio between the total number of species (taxa) and the total number of individuals. It removes the abundance variability among stations so that interstation comparisons are possible. This index expresses variety independent of an evenness index, which is incorporated in general indices of diversity. Diversity indices incorporate both species richness and evenness into a single value. The equation for Species Richness Index is:

$$d = \frac{S-1}{\log N}$$

where:

S = number of species
N = number of individuals

- **Simpson's Dominance Index (c)**, which varies from 0 to 1, gives the probability that two individuals drawn at random from a population belong to the same species (Ludwig and Reynolds 1988). The equation for Simpson's Dominance Index is:

$$c = \sum (ni / N)^2$$

where:

ni = importance value for each species
N = total of importance values

2.1.2 Fisheries Studies

Two sampling techniques, bottom trawl and beach seining, were employed to collect adult and juvenile fish species around James Island in June 2002. Fish and blue crabs were collected at ten locations (four beach seine locations and six bottom trawl) within and adjacent to the proposed dike alignments.

Bottom Trawl

Six bottom trawl locations (JF-001 through JF-006) were identified in the field which reflected the range of bottom conditions within or adjacent to the proposed alignments (Figure 2-2). Two otter trawl tows were conducted at each station, spaced several hundred feet apart. The gear employed was a 16-foot semi-balloon otter trawl with a ¾" liner. While the net was being deployed, DGPS coordinates were recorded at the beginning and end of each tow (Appendix B). Two separate five-minute tows were conducted at each of the six locations at a constant boat speed of 1,300 revolutions per minute (rpm). Longer tows were not possible due to obstructions such as crab pots and downed trees. The two tows at each location were conducted parallel to the prevailing currents, tidal flow or wind, which ever was greater. A 7:1 warp-to-tow ratio was used at all times to ensure that the net was fishing on the bottom. Upon completion of each five-minute tow, the trawl was emptied into a container and processed before conducting the second tow.

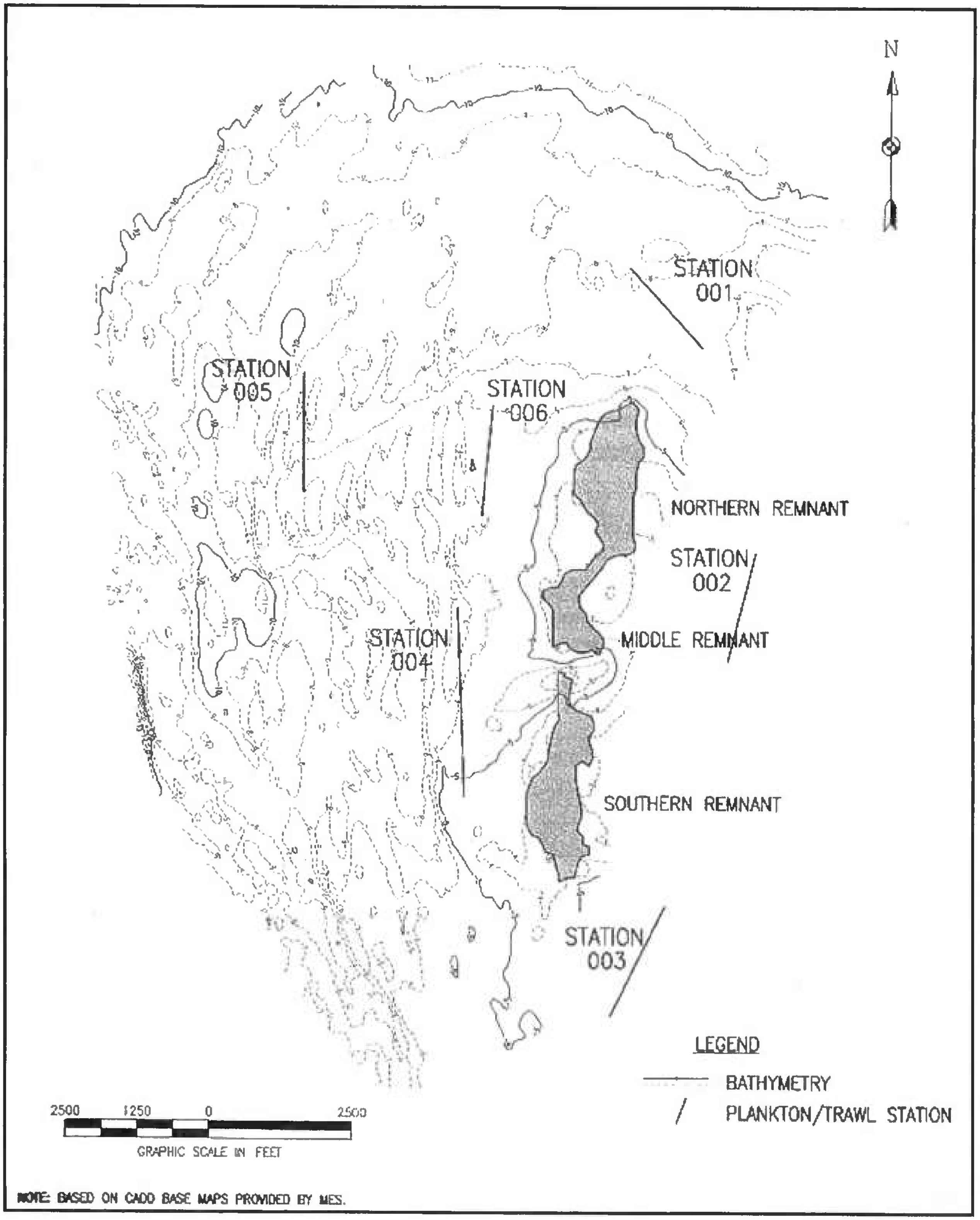


Figure 2-2. Plankton / Trawl Stations in Vicinity of James Island, June 2002

Trawl samples were processed onboard, and organisms were identified, enumerated and returned to the water. A representative subsample of fifty individuals per species from each tow were to be measured to the nearest millimeter, however, no species collected numbered enough to warrant subsampling at any of the six locations. Measurements included total lengths of finfish and carapace widths of blue crabs. Data were recorded on standard fisheries datasheets. Organisms having external parasites, disease, or morphological abnormalities were noted on the datasheet. Organisms collected during the two tows at a single location were numerically combined to represent ten-minutes of total effort for summarization purposes. *In situ* water quality parameters were recorded at each of the six locations.

Beach Seine

Four locations (Seines #1 through #4) were identified in the field, and were chosen to reflect a range of shore conditions within and adjacent to the proposed alignments (Figure 2-2). Because of the many snags and variable bottom conditions around much of the island remnants, the locations chosen were the areas that could be sampled effectively by seining; the locations are shown on Figure 2-3. Seine #1 was located on the eastern side of the south end of the northern remnant. Seine #2 was located on the western side of the north end of the middle remnant. Seine #3 was located in a small cove on the eastern side of the southern remnant. Seine #4 was located on the eastern side of the north end of the middle remnant. Locations were chosen to represent as many types of shore-zone habitat as possible and to distribute the seine sites between the western and eastern sides of the island. Three sites (Seines #1, #3, and #4) were located on the eastern side of the island and one site (Seine #2) was located on the western side of the island. Seine #2 was the only suitable location on the western side of the island to deploy the beach seine.

A 100-foot by 4-foot seine net with ¼ inch mesh was used to sample these locations. The net was deployed in an arc, perpendicular to the shoreline to sample approximately 30 meters of shoreline. Two consecutive and adjacent hauls were conducted at each of the four sites for a combined shoreline distance of approximately 60 meters. All finfish and blue crabs were emptied into a container and processed before conducting the second haul.

Seine samples were processed onshore, and organisms were identified, enumerated and returned to the water. A representative subsample of fifty individuals per species from each haul was measured to the nearest millimeter. Measurements included total lengths of finfish and carapace widths of blue crabs. Data were recorded on standard fisheries datasheets. Organisms having external parasites, disease, or morphological abnormalities were noted on the datasheet. Organisms collected during the two hauls at a single location were numerically combined for summarization purposes. *In situ* water quality parameters were recorded at each of the four locations.

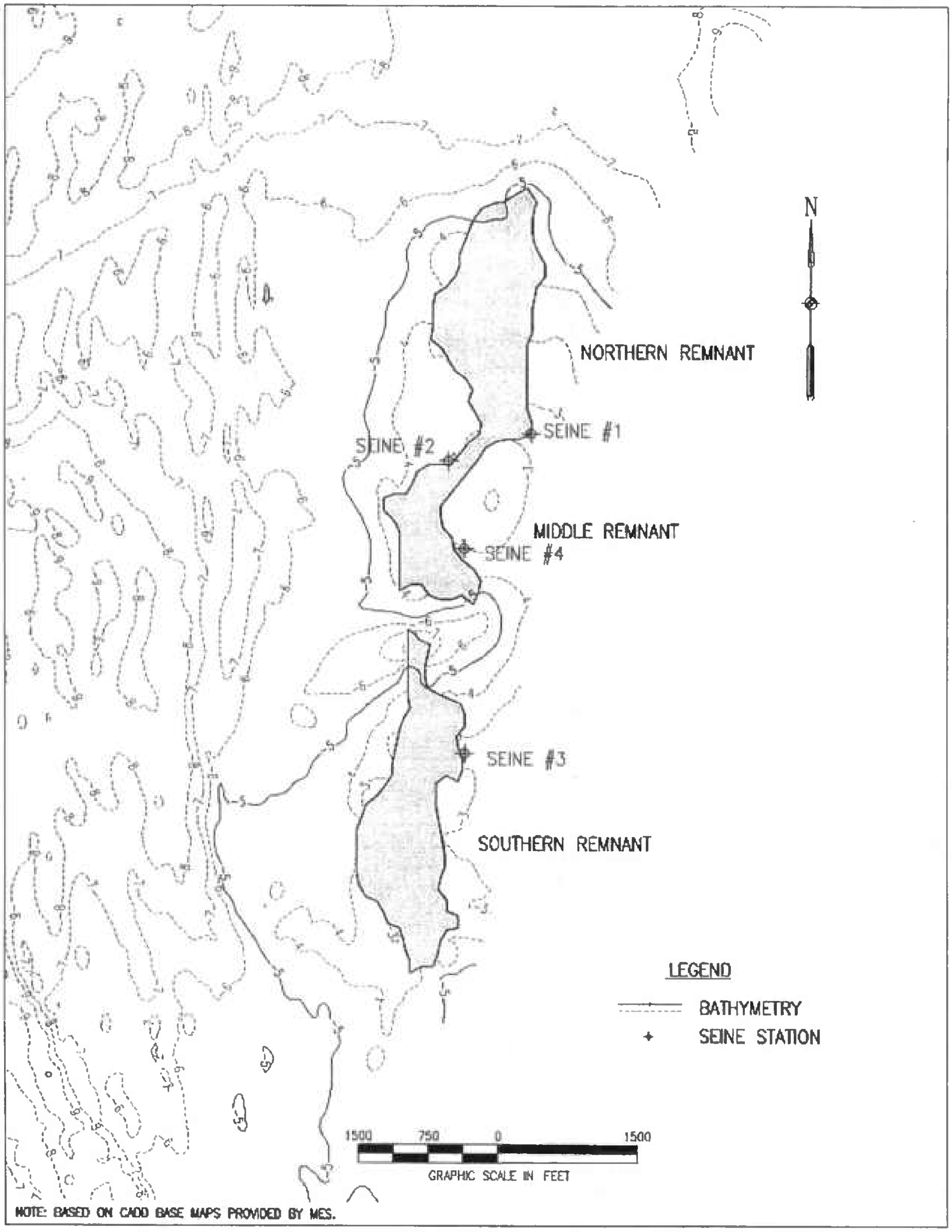


Figure 2-3. Seine Stations in Vicinity of James Island, June 2002

2.1.3 Plankton Studies

Plankton sampling was conducted at six locations, utilizing the same basic stations as the fisheries (trawl) locations (Figure 2-2). Two separate five-minute tows were conducted (one at the surface and one at the bottom). For each tow a constant boat speed of 1100 rpm was maintained. The gear utilized were two 2.5-m long, conical plankton nets with 0.5-m mouth openings, made from 505-micron mesh. These were mounted side-by-side on a rigid metal towing frame and sled, and 1-L plastic collection jars were screwed into the threaded codends. A General Oceanics digital flowmeter was affixed in the mouth of each net to record sample volume. A third flowmeter was attached to the sled frame outside of the nets for the purposes of monitoring net clogging. If substantially lower flowmeter readings were found in-net as compared to outside, the tow was repeated. Before deploying the plankton sled, 6-digit flowmeter readings were recorded from each of the three meters and DGPS beginning positions were recorded. The standard towing period was 5 minutes from the time that the nets were set and the tow was parallel to the prevailing currents. Longer tows were not possible due to jellyfish densities (which clog nets). Separate surface and bottom tows were conducted.

The amount of line deployed was calculated from a nomograph using the water depth and a cable angle. At the end of each tow, the final flowmeter and DGPS readings were recorded. The contents of each net were then rinsed, concentrating the catch into the codend jar. Sample jars were removed from the nets, labeled (inside and out), and preserved with 10 percent buffered formalin solution. At each station, mid-depth *in situ* water quality measurements were recorded.

In the laboratory, samples were rinsed using a 400-micron sieve to remove excess formalin. Detritus and debris were removed prior to sorting. Larger organisms were also removed and recorded. Samples were sorted completely and all fish eggs, larvae, and juveniles encountered were segregated for identification and enumeration. Ichthyoplankton were identified to the lowest practical taxon and enumerated. Macrozooplankton were also removed and enumerated by class. All observations were noted on standard laboratory sorting sheets. The remaining sample was recondensed and represerved for storage.

Plankton are reported as densities per 100 m^3 (#/100m^3). This was done by converting the net (final minus initial) flowmeter reading to a distance and volumes (based upon the net-mouth opening), then extrapolating the catches to the number of organism per 100 m^3.

2.1.4 Sediment Quality

Field Methods

Sediment quality sampling for James Island consisted of physical and chemical characterization of the bulk sediment and water quality measurements from five of the designated benthic locations: JAM-002, -005, -007, -009, and -010 (Figure 2-1, and Section 2.1.1).

Sediment sample collection for James Island was initiated on 12 November 2001 and completed on 13 November 2001. Five stations were successfully sampled using a medium-sized ponar grab (0.5 m^2) and samples were processed in the field following sediment collection. Multiple sediment grabs were collected and composited into one sample for each of the five locations.

Each sample was homogenized until the sediment was thoroughly mixed and of uniform consistency. When compositing and homogenization was complete, sub-samples of sediment were placed into appropriate sample jars and stored in a cooled (4°C) insulated container until submission to the laboratory for analyses.

Laboratory Methods

The analytical testing of sediment was conducted by Severn Trent Laboratories-Pittsburgh (STL-Pittsburgh) located in Pittsburgh, Pennsylvania. The standard methods recommended by the Inland Testing Manual (ITM) were used to analyze the sediment samples (USEPA/USACE 1998). Sediments were tested for the following compounds:

- semivolatile organic compounds (SVOCs),
- chlorinated pesticides,
- organophosphorus pesticides,
- polychlorinated biphenyl (PCB) congeners,
- polynuclear aromatic hydrocarbons (PAHs),
- metals,
- dixon and furan congeners,
- butyltins,
- ammonia (NH_3-N),
- nitrate/nitrite,
- cyanide
- total sulfide,
- total Kjeldahl nitrogen (TKN),
- acid volatile sulfide (AVS),
- simultaneously extracted metals (SEM),
- total organic carbon (TOC),
- total phosphorus,
- biochemical oxygen demand (BOD), and
- chemical oxygen demand (COD).

In addition, the following physical analyses were conducted for the bulk sediment samples:

- grain size determination,
- specific gravity, and
- moisture content.

Calculations for Total PCBs, Total PAHs, and Dioxin TEQs

For each sample, total PCB concentrations were determined by summing the concentrations of the 18 summation congeners (as specified in Table 9-3 of the ITM) and multiplying the total by a factor of 2. Multiplying by a factor of 2 estimated the total PCB concentration and accounted for additional congeners that were not tested as part of this program. These determinations were based upon testing of specific congeners recommended in the ITM and upon the National Oceanic and Atmospheric Administration (NOAA 1993) approach for total PCB determinations.

Total PAH concentrations were determined for each sample by summing the concentrations of the individual PAHs. For both the total PCB and total PAH concentrations, two values are reported, each representing the following methods for treating concentrations below the analytical detection limit:

- Non-detects = 0 (ND=0)
- Non-detects = 1/2 of the detection limit (ND = 1/2DL)

Substituting one-half the detection limit for non-detects (ND=1/2DL) provides a conservative estimate of the concentration. This method, however, tends to produce results that are biased high, especially in data sets where the majority of samples are non-detects. This overestimation is important to consider when comparing the calculated total values to criteria values.

The Toxicity Equivalency Quotients (TEQs) for dioxin were calculated following the U.S. Environmental Protection Agency (USEPA) approach (USEPA 1989). Each congener was multiplied by a Toxicity Equivalency Factor (TEF) (Van den Berg et al. 1998), and the congener concentrations were summed. The dioxin TEQs were calculated using ND=0 and ND=1/2DL.

2.2 TERRESTRIAL SURVEYS

2.2.1 Vegetation Surveys

Vegetative communities and habitat types observed at James Island in November 2001 and June 2002 were categorized by field reconnaissance activities and the documentation of data during field activities to the three island remnants. Additionally, aerial photographs, maps, and field notes from previous investigations of James Island were also used to determine the community types present at James Island (MES 2002). The intent of the vegetation characterization component of this investigation was to identify the distribution and composition of plant communities present such as low marsh, high marsh, upland, open water, and SAV habitats. The plant species composition of these areas were determined in terms of dominant and sub-dominant plants (by visual dominance estimation) determined to the genus and species, where possible. In October 2001, approximately 70 percent of the 3 island remnants was traversed by one EA scientist that made notes on general habitat types. In June 2002, two EA scientists traversed approximately 75 percent of the northern, middle, and southern remnants of James Island and more detailed floristic and habitat observations were recorded. Dominant plant species and vegetative communities encountered during the vegetation survey were documented on data sheets and observations were recorded with a digital camera in the field and downloaded in the office as a photographic record (Appendix A). Observed plant species were identified in the field and characterized by natural resource type and qualitative data was recorded concerning the distribution and extent of plant communities. Details of the botanical species observed within each habitat type or natural resource were recorded on the data sheets. Other general observations including wildlife species and topography characteristics were also noted.

2.2.2 Avian and Other Wildlife

Timed bird survey observations were made during June 2002. Five stations around the perimeter of the three remnants of James Island (Figure 2-4) were established in order to observe the range of habitat types available around the island which included forests, wetlands, open water, SAV, and beaches. At each station, a timed bird survey was conducted covering a 180-degree observation area. Each survey was 15 minutes in length. All species heard and/or observed with binoculars during the 15-minute period were recorded on data sheets. The data sheet consisted of four sections: sample information (e.g., date, time, location, weather conditions), habitat checklist, a bird species checklist and an area for notations. The checklist portion of the field data sheet had been developed for use as a generic field data sheet.

Bird species considered relatively common over a wide diversity of habitat types and seasons were listed in the checklist. Bird species were listed in taxonomic order and broken into categories as follows:

- Loons-Herons
- Geese-Ducks
- Vultures-Hawks
- Game Birds
- Shorebirds
- Gulls
- Doves-Cuckoos
- Owls
- Nightjars-Swifts
- Hummingbirds
- Kingfishers
- Woodpeckers
- Flycatchers
- Shrikes
- Vireos
- Jays-Crows
- Larks
- Swallows
- Titmice-Chickadees
- Creepers-Nuthatches
- Wrens
- Kinglets-Gnatcatchers
- Thrushes
- Mimics
- Starlings-Waxwings
- Warblers
- Tanagers
- Towhees-Sparrows
- Cardinals-Grosbeaks
- Blackbirds
- Finches
- Old World Sparrows

The approach for surveying birds associated with the three remnant portions of James Island was to make observations of a portion of a remnant and adjacent open water. The survey methods were utilized to achieve the desired results of documenting avian utilization of the project area, particularly the tidal marsh, upland habitat, and adjacent tidal waters.

During the 15-minute observation period all avian species seen and/or heard were noted along with the method of observation. Individuals were enumerated when discernible. Evidence of former nesting on the James Island remnants was also noted when observed.

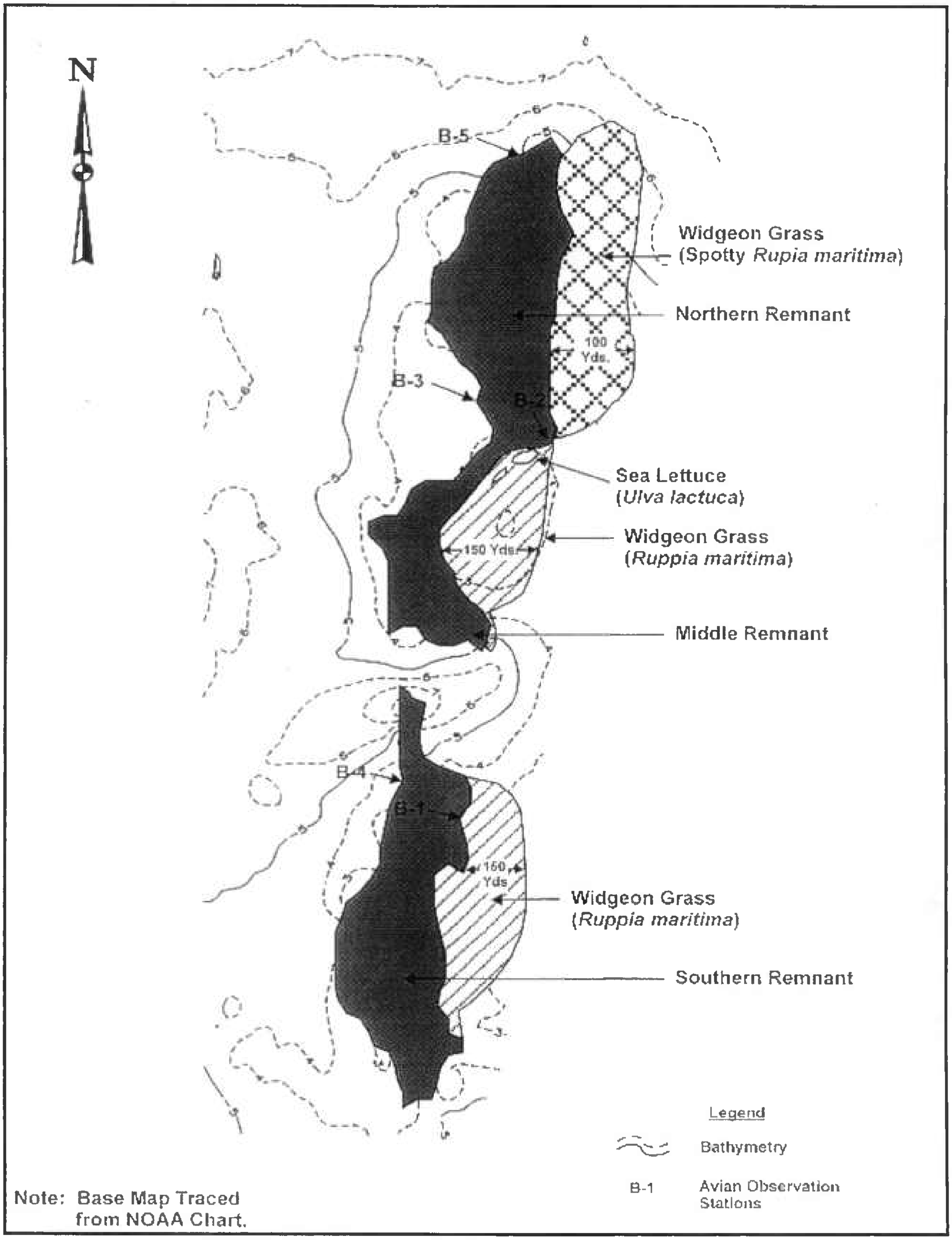


Figure 2-4. Avian Observation Stations and Extent of Submerged Aquatic Vegetation (SAV) on James Island

In addition to the timed avian observations, incidental bird species observed were noted during the James Island habitat characterization surveys in both October 2001 and June 2002. The avian field data form described above was utilized and the recorded observations followed the same methodology. During the vegetation and habitat characterization surveys on each island remnant, wildlife species and signs (e.g., tracks, scat, bones, etc.) observed were recorded. When possible, the total number of individual wildlife species was also noted. The notation box portion of the data sheet used to record any observations of other wildlife species.

2.2.3 Other Resources

During both the October 2001 and June 2002 surveys, observations concerning historical, archeological, and other resources were completed in concurrence with past field investigations and the vegetation, avian, and wildlife observations. The intent of this investigation was to identify the distribution and occurrence of possible historic and archeological resources that were [identified by the Maryland Historic Trust (MHT)] relative to the area proposed for construction. Approximately 70 to 75 percent of the northern, middle, and southern remnants of James Island were traversed by EA scientists and general historic and archeological observations were recorded, when applicable.

2.3 Submerged Aquatic Vegetation (SAV) Mapping

Annual SAV data were downloaded from the Virginia Institute of Marine Science (VIMS) website. The data included SAV mapping for the entire Bay interpreted from annual overflights. The period of record for this data was 1971 to 2000 and resulted in 22 years of data; not all years were flown during the period of record. Data for 2001 and 2002 were not available at the time that this report was prepared. The available data were superimposed on maps of the area and compared to the proposed alignments for James Island Restoration.

In addition, the extent and relative density of SAV existing near James Island during the June 2002 field efforts was also noted in the field (Figure 2-4). EA scientists toured the island by perimeter in a boat to identify the general extent of the existing beds (visually). The boat was then set at the edge of the areas containing SAV and the width of the bed (to the shoreline) was measured using a range finder. All observations were drawn on a map. The SAV mapping was a qualitative survey and total SAV bed acreages were not generated at the feasibility-level of this study.

3.0 RESULTS AND ANALYSIS

3.1 AQUATIC SURVEYS

The field sampling programs were designed to assess the existing aquatic resources within and adjacent to the proposed alignments at James Island. The proposed design (baseline) area and the resulted total affected acreages are summarized below.

TABLE 3-1. DESIGN AND AFFECTED ACREAGES OF THE JAMES ISLAND ALIGNMENTS*

Alignment Number	Total Design Acreage	Total Upland Acreage	Total Wetland Acreage
1	978	489	489
2	2,126	1,063	1,063
3	1,586	793	793
4	2,200	1,100	1,100
5	2,072	1,036	1,036

*Note: This table presents the design acreages to the centerline of the project. Total site designs of the projects would be approximately one to two acres more to the toe of the dike, totaling 979 to 2,202 acres.

3.1.1 Benthic Community

Results of the benthic community evaluations are included, by season, in the following sections and in detail in Appendix C. Water quality was analyzed at each of the ten benthic stations during both the Fall 2001 and Summer 2002 surveys. Figure 2-1 in Section 2 presents the benthic sampling station locations.

3.1.1.1 October 2001

A taxonomic list of the benthic macroinvertebrates collected from James Island in October 2001 is presented in Table C-1 (Appendix C). Mean densities for each benthic macroinvertebrate collected at each station is presented in Table C-2 (Appendix C).

Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI)

A summary of the benthic community metrics and scores used to calculate the B-IBI for the October 2001 collection at James Island is presented in Table 3-2. Abundance (total number of organisms per square meter) was high at all stations except for JAM-010 (4,304/m^2). The remaining abundances ranged from 32,144/m^2 at JAM-001 to 356,000/m^2 at JAM-008, which resulted in B-IBI scores of 1 at all stations except for JAM-010 which received a score of 3. The Shannon-Weiner Diversity values were low, ranging from 0.025 at JAM-008 to 1.252 at JAM-010. All stations received a B-IBI score of 1 for the Shannon-Weiner Diversity metric. The abundance of stress-sensitive taxa was also low ranging from 0.03 percent at JAM-008 to 1.6 percent at JAM-001, resulting in B-IBI scores of 1 at all stations. The abundance of Stress-indicative taxa was below 1 percent for all stations resulting in all stations receiving a B-IBI

TABLE 3-2. SUMMARY OF BENTHIC COMMUNITY METRICS AND SCORES USED TO CALCULATE THE B-IBI AT JAMES ISLAND, OCTOBER 2001

Type of Metric	Metric Values by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004[c]	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010[c]
Abundance (#/m^2)[a]	32,144	72,216	219,157	49,021	92,350	251,307	98,266	356,000	191,821	4,304
Shannon-Weiner Diversity[a][b]	0.269	0.071	0.068	0.436	0.067	0.051	0.035	0.025	0.073	1.252
Stress-Sensitive Taxa Abundance (%)	1.6	0.1	0.1	--	0.1	0.1	0.1	0.03	0.2	--
Stress –Indicative Taxa Abundance (%)	0.1	0.01	<0.01	--	0.04	<0.01	0.01	<0.01	0.01	--
Carnivore/Omnivore Abundance (%)	2.8	0.6	0.8	4.4	0.6	0.3	0.3	0.1	0.7	37.0

Type of Metric	B-IBI Scores by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004[c]	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010[c]
Abundance (#/m^2)[a]	1	1	1	1	1	1	1	1	1	3
Shannon-Weiner Diversity[a][b]	1	1	1	1	1	1	1	1	1	1
Stress-Sensitive Taxa Abundance (%)	1	1	1	--	1	1	1	1	1	--
Stress –Indicative Taxa Abundance (%)	5	5	5	--	5	5	5	5	5	--
Carnivore/Omnivore Abundance (%)	1	1	1	1	1	1	1	1	1	5
B-IBI[d]	1.8	1.8	1.8	1	1.8	1.8	1.8	1.8	1.8	3

(a) Includes all species collected.
(b) Log used was log base e
(c) JAM-004 and JAM-010 are classified as high mesohaline mud; therefore, stress-sensitive taxa abundance and stress-indicative taxa abundance were not included in the calculation of the B-IBI.
(d) Mean of the metric scores.

score of 5. Stress-sensitive and stress-indicative taxa were not calculated at the high mesohaline mud stations JAM-004 and JAM-010. The abundance of carnivore/omnivore taxa was low at all stations except for JAM-010 (37 percent). The remaining abundances of carnivore/omnivore taxa ranged from 0.1 percent at JAM-008 to 2.8 percent at JAM-001, resulting in scores of 1 for all stations except JAM-010 which received a score of 5. The scores for each of the metrics at each station were averaged to determine the total B-IBI for each station. Scores of 3.0 or greater are considered to meet the Chesapeake Bay Restoration Goal. Total B-IBI scores were low (1.0 – 1.8) for stations JAM001-009 sampled at James Island in October 2001. JAM-010, which had a total B-IBI score of 3.0, was the only station sampled in the proposed alignment areas in October 2001 to meet the Chesapeake Bay Restoration Goal.

Other Benthic Community Metrics

Four additional metrics were calculated to further characterize the benthic community and include the total number of taxa (collected at each station), species richness, evenness, and the Simpson's Dominance Index (Table 3-3).

A total of 35 separate benthic taxa (only species meeting B-IBI macrofaunal criteria were included) were collected in October 2001 at James Island (Table C-2). The annelids comprised the most taxa (16); bivalves (5); crustaceans (5); nemerineans (5); and gastropods (4). The total number of taxa varied at James Island, ranging from 9 taxa at JAM-007 to 23 taxa at JAM-004.

Species richness was similar at all stations ranging from 1.04 at JAM-007 to 2.81 at JAM-004 (Table 3-3). Evenness was low at all stations except for JAM-010 (0.47). The remaining values for evenness ranged from 0.01 at JAM-007 and JAM-008 to 0.13 at JAM-004.

Station JAM-010 had the lowest value for dominance and the highest evenness value. However, total number of taxa was low at this station. Station JAM-007 had the lowest values for evenness and species richness, and one of the highest for dominance. This station also had the lowest total number of taxa.

Simpson's Dominance Index values were high at all stations at James Island in October 2001, except for JAM-010 (0.395). The remaining values ranged from 0.848 at JAM-004 to 0.988 at JAM-006 (Table 6). All stations were dominated by the gem clam.

Abundance Trends

Bivalvia was the most dominant group found at the benthic stations (Table C-2 of Appendix C). Seven stations (JAM-002, JAM-003, JAM-005, JAM-006, JAM-007, JAM-008, JAM-009) had at least 99 percent dominance of bivalves. Bivalves also dominated at the remaining stations, JAM-001 (95.7 percent), JAM-004 (92 percent), and JAM-010 (55.4 percent). The dominant bivalve was the gem clam. Annelids were the second most dominant group found at the benthic stations. They were found at all stations with the highest abundance occurring at JAM-001 (2.5 percent), JAM-004 (7.4 percent), and JAM-010 (34.9 percent). The dominant annelids were the polychaetes *Glycinde solitaria* and *Neanthes succinea.*

TABLE 3-3. SUMMARY OF ADDITIONAL BENTHIC COMMUNITY METRICS[(a)] AT JAMES ISLAND, OCTOBER 2001,

Type of Metric	Values by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010
Total # of Taxa[(b)]	19	12	15	23	12	17	9	16	18	11
Species Richness	2.36	1.62	1.64	2.81	1.37	2.0	1.04	1.93	2.24	2.02
Evenness	0.09	0.03	0.02	0.13	0.03	0.02	0.01	0.01	0.02	0.47
Simpson's Dominance Index	0.917	0.982	0.981	0.848	0.983	0.988	0.992	0.995	0.981	0.395

(a) Includes all species collected.
(b) Excludes species not meeting B-IBI macrofaunal criteria.

Water Quality and Precipitation Data

In situ water quality collected during the benthic sampling for Fall 2001 is discussed in Section 3.1.2 and Table 3-7. The months preceding the October 2001 sampling event at James Island exhibited below to well below normal precipitation events. The NOAA reported that the average precipitation in September 2001 was 2.2 in. and in October it was 0.90 in. in the vicinity of James Island (NOAA 2002). September 2001 was classified as below normal (one of the 35 driest such periods on record) and October 2001 was classified as much below normal (one of the 10 driest such periods on record).

Summary of Fall 2001 Benthic Findings

Abundance (total number of organisms per square meter) was high at James Island in the October 2001 collection. Abundance ranged from 4,304/m^2 at JAM-010 to 356,000/m^2 at JAM-008. Bivalvia was the most dominant group found at the benthic stations. Seven stations (JAM-002, JAM-003, JAM-005, JAM-006, JAM-007, JAM-008, and JAM-009) had at least 99 percent dominance of bivalves. Bivalves also dominated at the remaining stations, JAM-001 (95.7 percent), JAM-004 (92 percent), and JAM-010 (55.4 percent). The dominant bivalve was the gem clam.

Overall, the B-IBI metric calculations were low at stations collected near James Island. The Shannon-Weiner Diversity values ranged from 0.025 at JAM-008 to 1.252 at JAM-010. The abundance of stress-sensitive taxa ranged from 0.03 percent at JAM-008 to 1.6 percent at JAM-001 and the abundance of stress-indicative taxa was below 1 percent for all stations. The abundance of carnivore/omnivore taxa was low at all stations (0.1 to 2.8 percent) except for JAM-010 (37 percent).

In conclusion, the total B-IBI scores were also low (ranging from 1.0 to 1.8) for all stations sampled at James Island in October 2001 except for JAM-010, which had a total B-IBI score of 3.0. Scores of 3.0 or greater were considered meeting the Chesapeake Bay Restoration Goal (Ranasinghe et al. 1994). JAM-010 was the only station sampled in October 2001 to meet the Chesapeake Bay Restoration Goal. The mean total B-IBI score for the combined James Island sites was 1.8.

The low B-IBI scores may be related to a combination of factors: below normal precipitation for the months of September and October preceding the 24 – 30 October 2001 sampling event and the predominance of one species (gem clam) at all the stations.

3.1.1.2 June 2002

A taxonomic list of the benthic macroinvertebrates collected from James Island in June 2002 is presented in Table C-1 (Appendix C). Mean densities for each benthic macroinvertebrate collected at each station is presented in Table C-3.

Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI)

A summary of the benthic community metrics and scores used to calculate the B-IBI for the June 2002 collection at James Island is presented in Table 3-4. Overall, low B-IBI scores were encountered at all stations sampled in June 2002. Abundance (total number of organisms per square meter) was high at all stations ranging from 45,906/m^2 at JAM-010 to 351,145/m^2 at JAM-006, which resulted in B-IBI scores of 1 at all stations. The Shannon-Weiner Diversity values were low, ranging from 0.02 at JAM-007 to 0.412 at JAM-010. All stations received a B-IBI score of 1 for the Shannon-Weiner Diversity metric. The abundance of stress-sensitive taxa was also low ranging from 0.002 percent at JAM-006 to 0.049 percent at JAM-009, resulting in B-IBI scores of 1 at all stations. The abundance of stress-indicative taxa was below 2 percent for all stations resulting in all stations receiving a score of 5. Stress-sensitive and stress-indicative taxa were not calculated at the high mesohaline mud stations JAM-004 and JAM-010. The abundance of carnivore/omnivore taxa was low at all stations ranging from 0.112 percent at JAM-007 to 0.816 percent at JAM-004, resulting in scores of 1 for all stations.

The scores for each of the metrics at each station were averaged to determine the total B-IBI for each station. Scores of 3.0 or greater are considered as meeting the Chesapeake Bay Restoration Goal. Total B-IBI scores were low (1.0 to 1.8) for all stations sampled at James Island in June 2002. No stations sampled in June 2002 met the Chesapeake Bay Restoration Goal.

Other Benthic Community Metrics

Four additional metrics were calculated to further characterize the benthic community and include the total number of taxa collected at each station, species richness, evenness, and the Simpson's Dominance Index (Table 3-5).

A total of 41 separate benthic taxa (only species meeting B-IBI macrofaunal criteria were included) were collected in June 2002 at James Island (Table 3). Annelids comprised the most taxa (15); crustaceans (11); bivalves (5); nemerineans (4); and gastropods (4). The total number of taxa varied at James Island, ranging from 11 taxa at JAM-007 to 22 taxa at JAM-005.

Simpson's Dominance Index values were high at all stations at James Island in June 2002. The values ranged from 0.833 at JAM-010 to 0.996 at JAM-007 (Table 3-5). The gem clam dominated all stations.

TABLE 3-4. SUMMARY OF BENTHIC COMMUNITY METRICS AND SCORES USED TO CALCULATE THE B-IBI AT JAMES ISLAND, JUNE 2002

Type of Metric	Metric Values by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004[c]	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010[c]
Abundance (#/m^2)[a]	302,946	148,179	214,961	133,477	222,864	351,145	139,011	205,116	221,293	45,906
Shannon-Weiner Diversity[a][b]	0.142	0.151	0.087	0.249	0.079	0.087	0.020	0.068	0.070	0.412
Stress-Sensitive Taxa Abundance (%)	0.022	0.032	0.012	--	0.034	0.002	0.004	0.003	0.049	--
Stress –Indicative Taxa Abundance (%)	1.327	0.724	0.313	--	0.049	0.433	0.019	0.103	0.267	--
Carnivore/Omnivore Abundance (%)	0.381	0.498	0.274	0.816	0.298	0.269	0.112	0.291	0.213	0.80

Type of Metric	Metric Values by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004[c]	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010[c]
Abundance (#/m^2)[a]	1	1	1	1	1	1	1	1	1	1
Shannon-Weiner Diversity[a][b]	1	1	1	1	1	1	1	1	1	1
Stress-Sensitive Taxa Abundance (%)	1	1	1	--	1	1	1	1	1	--
Stress –Indicative Taxa Abundance (%)	5	5	5	--	5	5	5	5	5	--
Carnivore/Omnivore Abundance (%)	1	1	1	1	1	1	1	1	1	1
B-IBI[d]	1.8	1.8	1.8	1	1.8	1.8	1.8	1.8	1.8	1

(a) Includes all species collected.

(b) Log used was log base e

(c) JAM-004 and JAM-010 are classified as high mesohaline mud; therefore, stress-sensitive taxa abundance and stress-indicative taxa abundance were not included in the calculation of the B-IBI.

(d) Mean of metric scores

TABLE 3-5. SUMMARY OF ADDITIONAL BENTHIC COMMUNITY METRICS[a] AT JAMES ISLAND, JUNE 2002

Type of Metric	Metric Values by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010
Total # of Taxa[b]	19	20	17	16	22	18	11	17	14	19
Simpson's Dominance Index	0.957	0.958	0.977	0.917	0.980	0.977	0.996	0.983	0.982	0.833
Species Richness	2.06	2.5	1.93	2.02	2.69	2.30	1.21	2.13	1.54	2.27
Evenness	0.05	0.05	0.03	0.08	0.02	0.03	0.01	0.02	0.02	0.14

(a) Includes all species collected.
(b) Excludes species not meeting B-IBI macrofaunal criteria.

Species Richness was similar at all stations ranging from 1.21 at JAM-007 to 2.69 at JAM-005 (Table 3-5). Evenness was low at all stations ranging from 0.01 at JAM-007 to 0.14 at JAM-010.

Station JAM-010 had the lowest value for dominance and the highest evenness value. Station JAM-007 had the lowest values for evenness and species richness, and the highest for dominance. This station also had the lowest total number of taxa.

Abundance Trends

Bivalvia was the most dominant group found at the benthic stations. All stations, except JAM-010, had at least 96 percent dominance of bivalves (Table C-3 of Appendix C). JAM-010 had 91 percent dominance of bivalves. The dominant bivalve was the gem clam; annelids were the second most dominant group found at the benthic stations. Annelids were found at all stations with the highest abundance occurring at JAM-010 (7 percent). The dominant annelid was the polychaete *Streblospio benedicti.*

Water Quality and Precipitation Data

In situ water quality collected during the benthic sampling for Summer 2002 is discussed in Section 3.1.2 and Table 3-7. The June 2002 sampling event at James Island exhibited below normal precipitation. The NOAA reported that the average precipitation in June 2002 was 2.39 inches in the vicinity of James Island (NOAA 2002). June 2002 was classified as below normal (one of the 35 driest such periods on record).

Summary of Summer 2002 Findings

Abundance (total number of organisms per square meter) was high at James Island in the June 2002 collection. Abundance ranged from 45,906/m^2 at JAM-010 to 351,145/m^2 at JAM-006. Bivalves were the most dominant group found at the benthic stations. All stations except JAM-010 (91 percent) had at least 96 percent dominance of bivalves. The dominant bivalve was the gem clam.

Overall, the B-IBI metric calculations were low at stations collected near James Island. The Shannon-Weiner Diversity values ranged from 0.02 at JAM-007 to 0.412 at JAM-010. The abundance of stress-sensitive taxa ranged from 0.002 percent at JAM-006 to 0.049 percent at JAM-009 and the abundance of stress-indicative taxa ranged from 0.019 percent at JAM-007 to 1.3 percent at JAM-010. The abundance of carnivore/omnivore taxa was low at all stations (0.1 to 0.8 percent).

In conclusion, the total B-IBI scores were also low (ranging from 1.0 to 1.8) for all stations sampled at James Island in June 2002. Scores of 3.0 or greater were considered meeting the Chesapeake Bay Restoration Goal (Ranasinghe et al. 1994). No stations sampled in June 2002 met the Chesapeake Bay Restoration Goal. The mean total B-IBI score for the combined James Island sites was 1.6. The low B-IBI scores may be related to a combination of factors: below normal precipitation for the month of June and the predominance of one species (gem clam) at all the stations.

3.1.2 Fisheries Studies

The fisheries results are summarized in the following sections, with more detailed summaries of the data included in Appendix C. A total of twenty finfish species, representing fifteen families and one crab species were collected during the sampling conducted during June 2002. The scientific and common names of all species collected with all gear types are listed in Table C-4 (Appendix C). Summaries of catches by gear type and station are presented in Table 3-6. A summary of the length data for all organisms measured is included as Table C-5 (Appendix C). *In situ* water quality collected during the field effort is included in Table 3-7.

Bottom Trawl

Bottom trawling efforts yielded very few fish at the six locations (Figure 2-2). A total of six species representing six families were collected using bottom trawl gear. Miscellaneous captures of mysid shrimp, mud crabs, crangon shrimp, stinging nettles and comb jellyfish were also captured. Comb jellyfish were very abundant at all six of the trawl stations, with an estimated volume of five to ten gallons collected at each station. Stations JF-001, JF-002, and JF-004 yielded no fish for the two consecutive tows at each of these locations. One Atlantic silverside (*Menidia menidia*) was collected at Station JF-006 and two blue crabs (*Callinectes sapidus*) were collected at Station JF-005. The trawl stations within the proposed alignments (JF-001, JF-004, JF-005, and JF-006) and the station immediately east of James Island (JF-002) had relatively uniform bottoms with little-to-no structural habitat features. Station JF-003 (between James and Taylor islands (Figure 2-2) had the most fish captures of the six bottom trawl locations. Five species were collected in the two consecutive tows, spot (*Leiostomus xanthurus*), bay anchovy (*Anchoa mitchilli*), northern pipefish (*Sygnathus fuscus*), naked goby (*Gobiosoma bosci*), and blue crab. This area had a slightly different bottom character with more variability and probably has better physical habitat features than the other sites.

Based on DGPS estimates of position, each five minute tow covered approximately 15 seconds of latitude, or 300 meters yielding a total of 600 meters of bottom area sampled for both tows at each location. Station depths and thus depth of sampling varied somewhat from station to station and are as follows: JF-001 was 8 feet, JF-002 was 8 feet, JF-003 was 10 feet, JF-004 was 6 feet, JF-005 was 9 to 10 feet and JF-006 was 6 to 7 feet.

TABLE 3-6 SUMMARY OF FISH COLLECTIONS IN THE JAMES ISLAND STUDY AREA, JUNE 2002

Species	Number of Fish Collected at Otter Trawl Stations						Number of Fish Collected at Seine Stations			
	JF-001	JF-002	JF-003	JF-004	JF-005	JF-006	Seine #1	Seine #2	Seine #3	Seine #4
Atlantic menhaden							11	1	1	
Blueback herring							2	1	7	
Bay anchovy			13				26			
Skilletfish							2	17	11	2
Halfbeak								1		
Atlantic needlefish							51	3		2
Mummichog							54		28	
Rainwater killifish								1	12	
Atlantic silverside						1	809	850	270	344
Northern pipefish			1				2	5	1	
Striped bass										1
Atlantic croaker								1		
Red drum									2	
Spot			2				231	114	56	309
Naked goby			2							1
Summer flounder								2	5	
Hogchoker								2		
Blue crab			9		2		8	48	31	45
Sheepshead minnow							12			
Blackcheek tonguefish							1			

Beach Seine

Seining yielded considerably more fish than trawling (Figure 2-3). Nineteen (19) finfish species representing 15 families (total) and one crab species were collected during seining. Atlantic silversides numerically dominated the collections, although spot were also collected in abundance at all stations. Most species collected were forage fish, although juveniles of recreationally important species (summer flounder) and commercially important species (e.g., menhaden, blueback herring, striped bass, and red drum) were also collected. Seine # 4 (on the eastern side of the middle remnant) yielded the least number of species but the most spot taken at any station. Seine # 1 was located adjacent to the marsh along the northeastern end of the spit (between the northern and middle remnants). This station yielded the highest numbers of species and total fish collected of any station. Seine #2, along the western side of the spit was the station in closest proximity to the proposed dike alignments. It was very similar in terms of both total catch and number of species to Seine #1. Seine #3 on the northeastern end of the southern remnant yielded the lowest overall catches but a similar number of species to Seines #1 and #2. SAV was present at all seine stations except Seine #2.

Fisheries Study Conclusions

All of the fish collected in June 2002 were typical of species that occur in mesohaline reaches of the Chesapeake Bay. The different gears employed as part of the fisheries study targeted both bottom dwelling species and those species utilizing shorezone habitats. Based upon the lengths of the fish collected, the seine yielded predominantly juveniles of most species. This is typical of the gear used and indicates that the shore areas of James Island are providing nursery habitat for many species. There did not appear to be a significant difference in collections that were made inside and outside the SAV beds with this gear. Although the otter trawls yielded less individuals, most were larger (adult or subadults) species that are associated with bottom dwelling habitats. The lack of diversity in the trawl collections is probably a result of the lack of diversity of bottom types in the area that were trawled. It is very likely that these areas are used for foraging but lack other habitat features that would cause fish to linger.

James Island is located in an area that may provide essential fish habitat (EFH) to nine fish species that are managed under the Magnuson-Stevens Fisheries Conservation Act. These nine fish species include summer flounder, windowpane flounder (*Scopthalmus aquosus*), bluefish, cobia (*Rachycentron canadum*), red drum (*Sciaenops ocellatus*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), Atlantic butterfish (*Perprilus triacanthus*), and black sea bass *(Centropristus striata*). Consultations with the National Marine Fisheries Service (NMFS) have indicated that bluefish, summer flounder, and red drum are the species of particular concern in the vicinity of James Island (Nichols 2002). Two species collected during the Summer 2002 fisheries study around James Island, including summer flounder and red drum, are considered species of concern and are managed under the Magnuson-Stevens Fisheries Conservation Act. The presence of these species of concern indicates that the waters around James Island may provide EFH. The waters around the island remnants support a variety of forage species that are known to be important food sources for the species of concern. Because SAV occurs adjacent to many of the remnants, James Island may also be providing Habitat of Particular Concern (HAPC) for summer flounder and red drum.

In Situ Water Quality

The water quality measurements taken at James Island during biological sampling efforts are summarized in Table 3-7. Depths in the areas sampled (other than at the seine stations) ranged from 4 to 13 feet (Figure 2-1). Salinities over both seasons ranged from 10.8 to 16.8 ppt. This is typical (although 10.8 ppt is somewhat low) for this reach of the Chesapeake Bay. Turbidity was low at all locations but somewhat elevated along the shoreline (seine stations), which is expected. Temperatures were consistent with the expected norms for fall (13.6 to 18.6 °C) and summer (24.1 to 26.9 °C) and pH was typical of waters of this salinity regime. Dissolved oxygen (DO) readings were atypical of shallow, well-mixed waters of the Bay at these salinities and temperatures. Fall readings between 10.2 and 12.9 mg/L are a bit high. The readings over 13 mg/ L are anomalous and reflect a membrane tear over the DO probe. The oxygen readings taken at the seine stations range 5.9 to 8.5 mg/ L and most otter trawl stations (ranges from 4.7 to 8.1 mg/L) are within the range expected at these temperatures, salinities and depths. There was one low (and probably anomalous) reading taken at one bottom trawl station (JF-003). All oxygen readings taken in June 2002 are lower than expected and reflect a meter malfunction due to a membrane tear over the DO probe during benthic and plankton sampling.

TABLE 3-7. *IN SITU* WATER QUALITY MEASUREMENTS TAKEN IN ASSOCIATION WITH BIOLOGICAL COLLECTIONS

Station	Depth (ft)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (ppt)	Turbidity (NTU)
Benthic Sampling—October 2001						
JAM-001	12.3	15.3	8.0	10.2	16.8	4.0
JAM-002	9.0	13.6	8.1	10.5	14.9	4.0
JAM-003	6.0	18.3	8.1	11.3	NR	1.6
JAM-004	11.0	18.1	8.1	11.1	NR	1.6
JAM-005	8.5	18.6	8.3	17.2	NR	1.4
JAM-006	13.0	18.5	8.3	13.6	NR	1.6
JAM-007	9.5	18.4	8.1	17.9	NR	2.3
JAM-008	8.0	13.9	8.5	10.3	14.9	4.0
JAM-009	9.5	17.9	8.2	12.9	NR	1.5
JAM-010	5.5	18.0	8.2	11.3	NR	1.4
Benthic Sampling—June 2002						
JAM-001	12.0	24.4	8.2	4.9	12.6	3.6
JAM-002	9.0	24.5	8.2	5.0	12.7	3.6
JAM-003	5.0	24.5	8.0	4.7	13.1	10.2
JAM-004	10.0	24.5	8.2	4.8	12.9	7.8
JAM-005	8.0	24.4	8.1	4.7	12.7	2.9
JAM-006	12.0	23.7	8.1	4.2	12.6	2.7
JAM-007	9.0	23.4	8.1	4.5	12.6	4.4
JAM-008	8.0	23.4	8.2	4.8	12.4	2.2
JAM-009	8.0	23.8	8.2	5.1	12.4	7.1
JAM-010	4.0	23.8	8.2	3.1	12.9	3.6
Plankton Trawl Sampling—June 2002						
JP-001	8.0	26.4	8.2	5.1	12.7	NR
JP-002	7.0	25.9	8.1	5.3	12.9	NR
JP-003	7.0	25.2	8.0	4.2	12.6	NR
JP-004	5.0	25.3	8.3	5.3	12.3	NR
JP-005	9.0	25.4	8.2	4.8	12.3	NR
JP-006	7.0	24.2	8.2	4.5	12.5	NR
Bottom Trawl Sampling—June 2002						
JF-001	8.0	23.8	8.1	4.7	12.5	4.2
JF-002	5.0	24.5	8.2	7.0	12.4	3.6
JF-003	9.0	24.0	8.0	3.6	12.0	6.3
JF-004	5.0	23.8	8.2	7.0	11.3	2.9
JF-005	9.0	24.1	8.4	8.1	10.8	1.4
JF-006	5.0	24.3	8.1	6.0	11.5	2.3

NR = No reading recorded

TABLE 3-7. (CONTINUED)

Station	Depth (ft)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (ppt)	Turbidity (NTU)
Beach Seine Sampling—June 2002						
Seine #1	0 to 3	26.9	8.5	8.5	12.6	68.2
Seine #2	0 to 3	26.6	8.2	8	12.4	35.5
Seine #3	0 to 3	24.3	8	6.9	12.4	39.5
Seine #4	0 to 3	25.7	8.2	5.9	12.3	8.1

NR = No reading recorded

3.1.3 Plankton Studies

Plankton sampling was conducted at the same stations as the trawl locations during the Summer 2002 surveys (Figure 2-2). The results of the ichthyoplankton analysis are summarized in Tables 3-8 (eggs) and Table 3-9 (larvae). Macrozooplankton results are included in Table 3-10. Eggs of four fish species were found in the plankton in the vicinity of James Island (Table 3-8). Collections were dominated numerically by bay anchovy eggs with densities ranging from 95 to 6754.1 eggs per $100m^3$ ($\#/100m^3$). The highest densities were found at Station JP-004, immediately west of the gap between the middle and southern remnants and there was little difference between surface and bottom samples at that station. Station JP-002 also yielded very high anchovy egg densities in bottom samples. Stations that yielded significant differences in densities between surface and bottom tows were JP-002 and JP-006. Weakfish eggs were found among the plankton and were the only lifestages of these species recorded in the fisheries field study.

Seven species of larval fish were identified in the plankton (Table 3-9). No larval form of any species dominated the plankton over all stations and depths. Gobies and skilletfish dominated the bottom tows at several locations (JP-002, JP-003, and JP-006). Blennies were ubiquitous, occurring throughout the water column at most stations. Atlantic silversides were more prevalent in surface tows at most stations and bay anchovy tended to be more prevalent in bottom tows. JP-003 yielded the highest overall larval fish densities and the high numbers of gobies in that area caused this phenomenon. This observation is consistent with the otter trawl collections in that area. Stations JP-002 (east of James Island) and JP-006 (immediately west of the northern remnant) also yielded fairly high densities, driven by the presence of gobies.

The fish eggs and larvae found in the plankton near James Island in June 2002 were typical of this reach of the Bay in summer. The relatively high densities of some species indicate that the waters surrounding the island remnants are providing relatively good fish habitat, which is consistent with the results of the seine investigation.

The macroinvertebrates found in the plankton near James Island during the Summer 2002 sampling effort are summarized in Table 3-10. Crab zoea numerically dominated collections at most stations at both the surface and bottom, although shrimp larvae and amphipods were very abundant in some places. Similar to the fish egg results, the highest zooplankton densities were found at JP-004. The lowest overall densities were found at station JP-001 and JP-003. Zooplankton distributions showed a much clearer trend of higher overall densities at the bottom at most sites. This is consistent with zooplankton diel trends. The plankton found near James are typical of those found in the plankton throughout mesohaline portions of the Bay and are helping to support the fisheries community near James Island and in adjacent areas of the Bay.

TABLE 3-8. SUMMARY OF FISH EGG DENSITIES (#/100m^3) IN THE VICINITY OF JAMES ISLAND, JUNE 2002

Species Collected	Station Number											
	JP-001				JP-002				JP-003			
	Surface		Bottom		Surface		Bottom		Surface		Bottom	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bay anchovy	1138.5	1604.5	1586.4	1642.5	471.8	359.4	4426.7	4270.6	998.6	1340.0	719.4	688.1
Naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	3.9
Weakfish	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	27.3	11.0	9.4	3.9
Hogchoker	3.0	5.9	2.4	1.2	0.0	3.7	2.9	3.5	12.4	17.1	6.7	15.6

Species Collected	Station Number											
	JP-004				JP-005				JP-006			
	Surface		Bottom		Surface		Bottom		Surface		Bottom	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bay anchovy	5913.6	6754.1	5399.9	5018.4	1688.3	1808.4	1930.1	1772.5	153.6	95.0	2605.4	3114.5
Naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weakfish	1.3	1.3	1.4	1.4	0.0	0.0	0.0	2.5	25.6	17.2	52.1	33.7
Hogchoker	0.0	0.0	1.4	1.4	0.0	0.0	0.0	2.5	1.3	4.0	41.4	71.4

TABLE 3-9. SUMMARY OF LARVAL FISH DENSITIES (#/100m^3) IN THE VICINITY OF JAMES ISLAND, JUNE 2002

Species Collected	Station Number											
	JP-001				JP-002				JP-003			
	Surface		Bottom		Surface		Bottom		Surface		Bottom	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Blenny	1.48	2.94	1.19	5.76	0.00	0.00	2.93	0.00	2.48	2.44	4.02	0.00
Bay anchovy	0.00	1.47	0.00	1.15	0.00	0.00	1.46	4.72	0.00	0.00	6.70	3.90
Skilletfish	0.00	0.00	0.00	6.92	2.52	1.25	13.18	2.36	0.00	1.22	4.02	1.30
Atlantic silverside	0.00	1.47	0.00	0.00	1.26	8.73	1.46	0.00	3.72	0.00	0.00	0.00
Northern pipefish	0.00	0.00	2.37	1.15	1.26	0.00	2.93	2.36	2.48	2.44	2.68	0.00
Seahorse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naked goby	0.00	0.00	0.00	1.15	0.00	2.50	80.54	70.76	3.72	0.00	274.61	190.86

Species Collected	Station Number											
	JP-004				JP-005				JP-006			
	Surface		Bottom		Surface		Bottom		Surface		Bottom	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Blenny	25.72	33.12	16.81	15.00	2.54	2.53	1.48	1.27	4.04	17.16	0.00	3.89
Bay anchovy	0.00	0.00	16.81	5.46	0.00	0.00	1.48	5.09	0.00	0.00	17.35	29.85
Skilletfish	1.29	1.32	2.80	1.36	0.00	1.27	7.40	15.27	1.35	1.32	2.67	1.30
Atlantic silverside	3.86	5.30	0.00	1.36	0.00	0.00	0.00	0.00	21.56	17.16	0.00	0.00
Northern pipefish	1.29	0.00	1.40	9.55	0.00	0.00	5.92	0.00	0.00	2.64	0.00	0.00
Seahorse	1.29	0.00	0.00	1.36	0.00	0.00	0.00	0.00	0.00	1.32	0.00	0.00
Naked goby	6.43	1.32	21.01	9.55	0.00	2.53	2.96	3.82	1.35	1.32	96.10	90.84

TABLE 3-10. SUMMARY OF MACROZOOPLANKTON DENSITIES (#/100m^3) IN THE VICINITY OF JAMES ISLAND, JUNE 2002

Species Collected	Station Number											
	JP-001				JP-002				JP-003			
	Surface		Bottom		Surface		Bottom		Surface		Bottom	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Crab zoea	19.2	58.8	61.7	263.9	36.5	51.2	578.4	443.4	42.2	29.2	65.6	68.8
Shrimp larvae	3.0	5.9	8.3	27.7	6.3	5.0	29.3	31.8	63.3	32.9	54.9	67.5
Amphipoda	0.0	0.0	0.0	1.2	1.3	0.0	0.0	1.2	3.7	0.0	38.8	9.1
Isopoda	0.0	0.0	2.4	1.2	1.3	1.2	2.9	0.0	1.2	1.2	9.4	9.1
Polychaeta	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.2	3.7	0.0	7.8
Syngnathidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nematoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Species Collected	Station Number											
	JP-004				JP-005				JP-006			
	Surface		Bottom		Surface		Bottom		Surface		Bottom	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Crab zoea	297.0	727.3	785.8	1257.7	88.9	234.4	42.9	67.4	99.7	141.2	48.1	150.5
Shrimp larvae	27.0	60.9	30.8	19.1	7.6	11.4	72.5	44.5	40.4	43.6	61.4	62.3
Amphipoda	2.6	5.3	140.1	0.0	5.1	34.2	153.9	25.4	67.4	72.6	25.4	250.5
Isopoda	2.6	4.0	2.8	0.0	1.3	0.0	1.5	2.5	0.0	0.0	2.7	3.9
Polychaeta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
Syngnathidae	0.0	0.0	7.0	0.0	0.0	0.0	5.9	7.6	0.0	4.0	0.0	3.9
Nematoda	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9

3.1.4 Sediment Quality

Sediment quality results from the Fall 2001 sampling are detailed in Appendix D. An analysis of the results is included below.

Comparison to Sediment Quality Guidelines (SQGs)

Concentrations of detected analytes in sediment samples were compared to SQGs (Buchman 1999) for marine sediments to assess the sediment quality of on-site sediments. SQGs are used to identify potential adverse biological effects associated with contaminated sediments. Probable Effects Levels (PELs) and Threshold Effects Levels (TELs) are biological effects-based SQGs that have been applied to contaminated sediments in Florida and other areas of the southeastern United States (Buchman 1999; MacDonald et al. 1996). TELs represent contaminant concentrations below which adverse biological effects rarely occur. PELs represent contaminant concentrations above which adverse biological effects frequently occur. Contaminant values that fall between the TEL and PEL represent the concentrations at which adverse biological effects occasionally occur. TEL and PEL values are provided in Table 3-11.

Recent evaluations of large chemical and toxicity data sets (O'Connor et al. 1998; O'Connor and Paul 1999) have indicated that TEL/PEL screening is not a reliable method for predicting sample toxicity or for screening samples out as non-toxic. The studies indicate that:

- Not exceeding a TEL should reliably predict the absence of whole-sediment toxicity,
- Exceeding a PEL (much less a TEL) does not reliably indicate toxicity, and
- Many, perhaps even most, sediments that exceed one or more PELs are not toxic.

Since TELs/PELs are widely used despite their recently demonstrated over-sensitivity in predicting toxicity, the concentrations of contaminants in the sediments sampled in this project were compared to the TEL and PEL values for all chemical constituents for which TEL/PEL values have been developed. For dredged material evaluations, SQGs are used as a tool to assist with identification of constituents of potential concern (COPCs) and to provide additional weight of evidence in the evaluation [USACE–Waterways Experiment Station (WES) 1998].

TABLE 3-11. MARINE SEDIMENT QUALITY GUIDELINES (SQGs)

Chemical Name	Units	Threshold Effects Level (TEL)	Probable Effects Level (PEL)
METALS			
ARSENIC	MG/KG	7.24	41.6
CADMIUM	MG/KG	0.676	4.21
CHROMIUM	MG/KG	52.3	160.4
COPPER	MG/KG	18.7	108.2
LEAD	MG/KG	30.24	112.18
MERCURY	MG/KG	0.13	0.696
NICKEL	MG/KG	15.9	42.8
SILVER	MG/KG	0.73	1.77
ZINC	MG/KG	124	271
CHLORINATED PESTICIDES			
CHLORDANE	UG/KG	2.26	4.79
4,4-DDD	UG/KG	1.22	7.81
4,4-DDE	UG/KG	2.07	374.17
4,4-DDT	UG/KG	1.19	4.77
DIELDRIN	UG/KG	0.715	4.3
GAMMA-BHC	UG/KG	0.32	0.99
PAHs			
2-METHYLNAPHTHALENE	UG/KG	20.21	201.28
ACENAPHTHENE	UG/KG	6.71	88.9
ACENAPHTHYLENE	UG/KG	5.87	127.87
ANTHRACENE	UG/KG	46.85	245
BENZO(A)PYRENE	UG/KG	88.81	763.22
BENZO[A]ANTHRACENE	UG/KG	74.83	692.53
CHRYSENE	UG/KG	107.77	845.98
DIBENZ(A,H)ANTHRACENE	UG/KG	6.22	134.61
FLUORANTHENE	UG/KG	112.82	1493.54
FLUORENE	UG/KG	21.17	144.35
NAPHTHALENE	UG/KG	34.57	390.64
PHENANTHRENE	UG/KG	86.68	543.53
PYRENE	UG/KG	152.66	1397.6
PAHs, TOTAL	UG/KG	1684.06	16770.4
PCBs			
PCBs,TOTAL	UG/KG	21.55	188.79
SEMIVOLATILE ORGANIC COMPOUNDS			
BIS(2-ETHYLHEXYL)PHTHALATE	UG/KG	182.16	2646.51

Source: Buchman 1999

Bulk Sediment Results

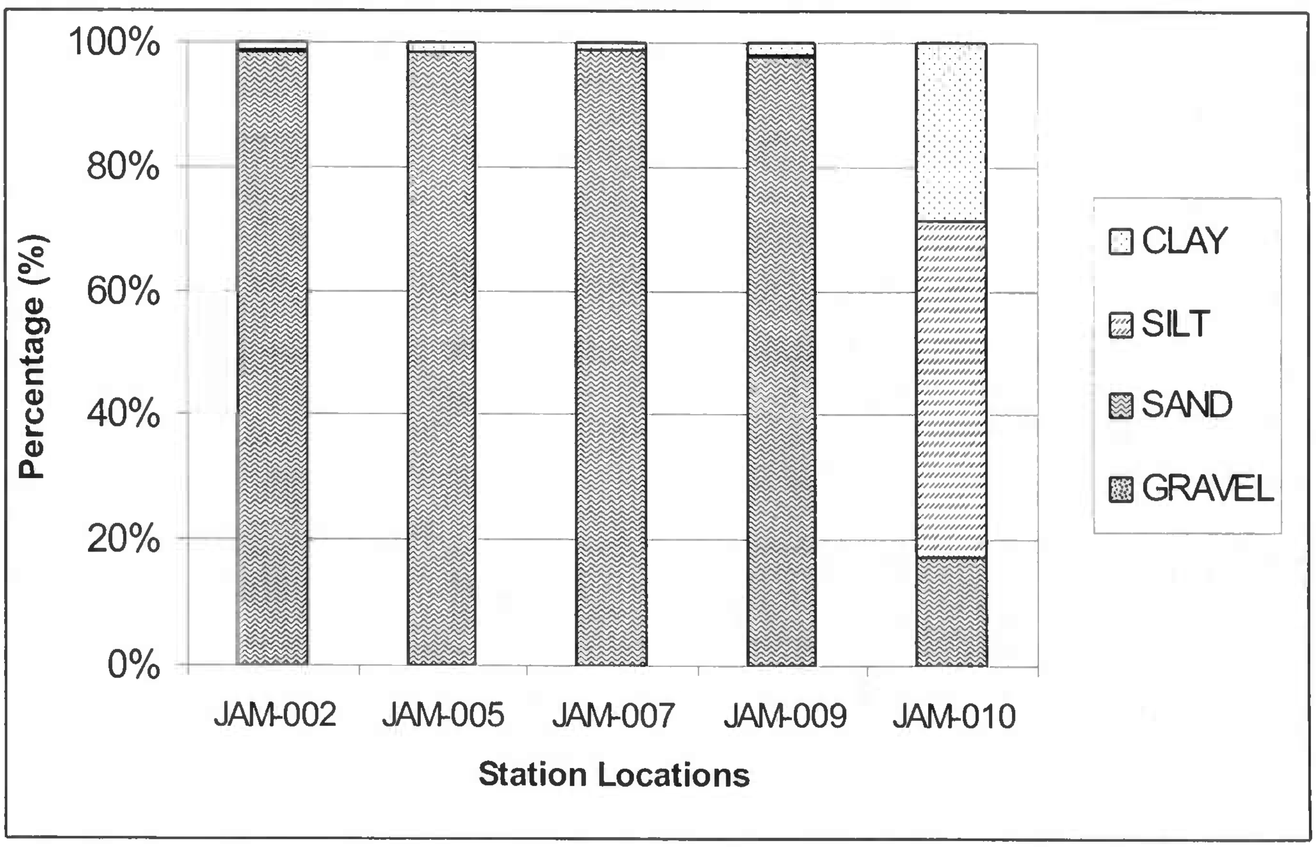
Results of the bulk sediment chemistry analyses for James Island sediment samples collected in November 2001 are presented in the following sub-sections. Bulk sediments were analyzed for target analytes and sample weights were adjusted for percent moisture (up to 50 percent moisture) prior to analysis to achieve the lowest possible detection limits. Analytical results are reported on a dry weight basis. Definitions of organic, inorganic, and dioxin and furan data qualifiers are presented in Tables D-1, D-2, and D-3, respectively.

Analytical results are provided in Tables D-4 through D-14. Values for detected chemical constituents are shaded and bolded in the data tables. Detection limits are presented for non-detected chemical constituents.

Physical Analyses

Results of the physical analyses are provided in Table D-4. Grain-size test results (Figure 3-1) indicated that the sediment around James Island was predominately comprised of sand (97.5 to 98.8 %) at all locations except for JAM-010, which was predominately comprised of silt-clay (82.8 %). Of the five James Island sediment samples, location JAM-007 had the highest proportion of sand (98.9 %), although both stations JAM-002 and JAM-005 also had high proportions of sand (98.4 %).

FIGURE 3-1. GRAIN SIZE DISTRIBUTION FOR BULK SEDIMENTS FROM JAMES ISLAND, FALL 2001



Nutrients and General Chemistry Parameters

Results of the nutrients and general chemistry parameters analyses are provided in Table D-5. Total organic carbon (TOC) concentrations ranged from 0.013 to 1.1 percent in the James Island sediments. The ammonia-nitrogen (NH_3-N) concentrations ranged from 2.4 to 28.4 mg/kg and total Kjeldahl nitrogen (TKN) concentrations ranged from 57.34 to 830 mg/kg. Nitrate and nitrite were detected at only one location, JAM-02, with a concentration of 0.005 mg/L. Biochemical oxygen demand (BOD) ranged from 155.8 to 753 mg/kg and chemical oxygen demand (COD) was only detected at location, JAM-002, with a concentration of 6.9 mg/L. Total phosphorus concentrations ranged from 12.92 to 98.2 mg/kg, total sulfide concentrations ranged from 0.768 to 85.8 mg/kg, and total cyanide concentrations ranged from 0.102 to 0.39 mg/kg.

Metals

Results of the metals analyses are provided in Table D-6. Of the 18 tested metals, thirteen were detected in the James Island sediments. Metals were detected in 59 of 90 cases (66 percent). Aluminum, arsenic, beryllium, chromium, cobalt, iron, lead, manganese, nickel, and zinc were detected in each of the samples. The majority of detected metals are naturally occurring and were measured at low concentrations. None of the detected metals had concentrations that exceeded TEL or PEL values.

The acid volatile sulfide (AVS)/ simultaneously extracted metals (SEM) ratio was greater than 1 at all locations (Table D-6). An AVS/SEM ratio greater than 1 indicates a high degree of probability that the metals are bound to organic material and not bioavailable to aquatic organisms. If the AVS/SEM is less than 1, then the metals in sediment exceed the binding ability and have a higher probability of being bioavailable to aquatic organisms. Therefore, most of the metals detected in James Island sediments would most likely not be available to aquatic organisms.

Polynuclear Aromatic Hydrocarbons (PAHs)

Results of the PAH analyses are presented in Table D-7. Of the 18 tested PAHs, two were detected in James Island sediments. PAHs were detected in 2 of 90 cases (2 percent). Benzo(a)pyrene was detected at low concentrations at location JAM010 and acenaphthylene was detected at location JAM002. Acenaphthylene exceeded the TEL value of 5.87 µg/kg by a factor of approximately 2.6. None of the tested PAHs were detected in sediment samples from locations JAM005, JAM007, and JAM009. None of the detected concentrations of PAHs exceeded PEL values.

Concentrations of total PAHs ranged from 0 to 15 µg/kg for ND=0 and 5.44 to 19.78 µg/kg for ND=1/2DL. Total PAH concentrations were below the TEL value of 1,684.06 µg/kg at all locations.

Polychlorinated Biphenyl (PCB) Congeners

Results of the PCB congener analyses are presented in Table D-8. Of the 26 tested individual PCB congeners, 10 were detected at low concentrations in James Island sediments. Individual PCB congeners were detected in 10 of 130 cases (8 percent). PCBs were detected only at sampling location JAM009. There are no TEL or PEL values for individual PCB congeners. The highest calculated total PCB concentration was approximately 3 times lower than the TEL of 21.55 μg/kg for total PCBs

Chlorinated and Organophosphorus Pesticides

Results of the chlorinated and organophosphorus pesticide analyses are presented in Tables C-9 and C-10, respectively. Of the 22 tested chlorinated pesticides, one was detected in the James Island sediments. Heptachlor was detected in low concentrations in sediments at all five sampling locations.

None of the five tested organophosphorus pesticides were detected in the James Island sediment samples.

Semivolatile Organic Compounds (SVOCs)

Results from the SVOC analyses are provided in Table D-11. Of the 41 tested SVOCs, none were detected in the James Island sediments.

Volatile Organic Compounds (VOCs)

Results from the VOC analyses are provided in Table D-12. Of the 34 tested VOCs, none were detected in the James Island sediments.

Dioxin and Furan Congeners

Results of the dioxin and furan analyses and associated Toxicity Equivalent Factors (TEFs) and Toxicity Equivalent Quotients (TEQs) are provided in Table D-13. The TEFs represent the toxicity of each congener relative to 2,3,7,8-TCDD (the most toxic congener). TEQs represent a weighted summation of all dioxin and furan congeners based on the toxicity of each congener relative to 2,3,7,8-TCDD.

Of the 17 tested dioxins, 16 were detected in the James Island sediment. Dioxins were detected in 73 of 85 cases (86%). OCDD, the least toxic dioxin congener, was detected at the highest concentration at all sampling locations. Dioxin TEQs for ND=0 ranged from 0.173 to 0.475 ng/kg and from 0.25 to 0.576 ng/kg for ND=1/2DL.

Butyltins

Results of the butyltin analyses are provided in Table D-14. Of the 4 tested butyltins, one was detected in the James Island sediment. Butyltins were detected in 1 of 20 cases (5 percent).

Dibutyltin was detected at low concentrations at sampling location JAM009. There are no TEL or PEL values for butyltins.

Summary of Sediment Quality Results

Results of the physical analyses indicated that the sediment around James Island was predominately comprised of sand (97.5-98.8%) at all locations except JAM-010, which was predominately comprised of silt-clay (82.8%). Of the five James Island sediment samples, location JAM-007 had the highest proportion of sand (98.9%), although both stations JAM-002 and JAM-005 also had high proportions of sand (98.4%).

Of the 155 chemical constituents tested in the sediment, 57 were detected in James Island sediments. The majority of these detected constituents were found in low concentrations, and were representative of background concentrations. SVOCs, VOCs, and organophosphorus pesticides were not detected in any of the sediment samples. One PAH, acenaphthylene, exceeded the TEL value at sampling location JAM-002 by a factor of approximately 2.6 but did not exceed PEL values. None of the other detected chemical constituents exceeded TEL values.

3.2 TERRESTRIAL SURVEYS

Terrestrial surveys were conducted concurrently with the avian surveys to map the existing vegetation during the Fall 2001 and Summer 2002 surveys. A photographic record of both the Fall 2001 and Summer 2002 terrestrial surveys are included as Appendix A of this report.

3.2.1 Vegetation Surveys

The northern, middle, and southern remnants of James Island consisted of high and low marsh areas, upland forest areas, open water habitats, sandy beaches, and pockets of SAV (Figure 3-1). All of the remnants are eroding (particularly along the nothern and western shorelines) which is resulting in bare ground, fallen trees, and compromised marshes. Erosion is exacerbated in some portions of the islands due to an apparently recent fire that has killed vegetation on both the northern and southern remnants. The low marshes are dominated by saltmarsh cordgrass (*Spartina alterniflora*) and the high marshes are dominated by saltmeadow cordgrass (*Spartina patens*) interspersed with saltgrass (*Distichlis spicata*) and the dominant shrub, marsh elder (*Iva frutescens*). The low marsh areas were often associated around the island remnants in a fringe fashion. Upland forest areas were evident in the central portions of all three island remnants and are dominated by almost monotypic stands of loblolly pine (*Pinus taeda*), although deciduous plant species including sycamore (*Platanus occidentalis*) and willow oak (*Quercus phellos*) also inhabit the upland areas. The majority of the wooded portions of the island remnants appear to be relatively mature and evidence of fairly recent fires on the island was observed.

James Island Northern Remnant

The northern remnant of James Island consists of natural resources that include open water habitats, wetland habitats (both high, low, and freshwater marshes), upland forest habitats, and SAV along the shorelines. Table 3-12 includes a cumulative list of plant species observed during the Fall 2001 and Summer 2002 surveys. A freshwater wetland with a surrounding berm was observed in the northern portion of the northern remnant with surface water and freshwater wetland plant species in the area. Loblolly pine is the dominant tree species in the northern remnant and monotypic stands were observed in the northern and middle portions of the northern remnant. Sycamore, aspen (*Populus* sp.), black cherry (*Prunus serotina*), and willow oak were observed as sub-dominant deciduous tree species among the non-monotypic loblolly pine stands, and American holly (*Ilex opaca*) was also observed interspersed with the loblolly pines. Loblolly pines that appeared to have been historically scorched by fire (trunks were burned) were observed along the western bank and also along the very turbid northern bank, where significant erosion is occurring.

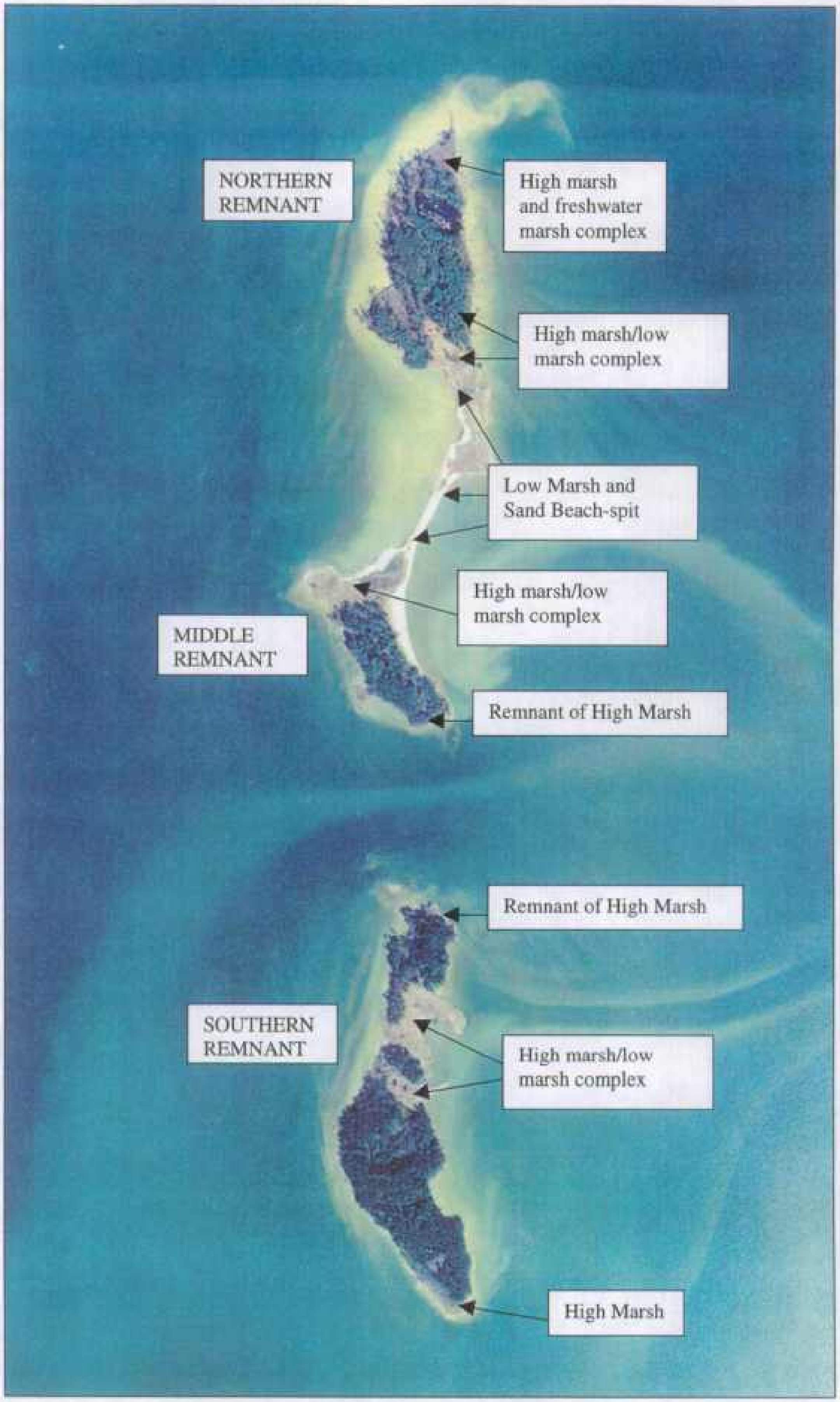


Figure 3-2. Location of marshes on James Island

TABLE 3-12. PLANT SPECIES OBSERVED ON THE NORTHERN AND MIDDLE REMNANTS OF JAMES ISLAND, FALL 2001 AND SUMMER 2002

Plant Group	Scientific Name	Common Name
Vines	*Lonicera japonica*	Japanese Honeysuckle
	Parthenocissus quinquefolia	Virginia Creeper
	Smilax rotundifolia	Greenbriar
	Toxicodendron radicans	Poison Ivy
Herbaceous plants	*Asclepias syriaca*	Common Milkweed
	Carex sp.	Sedge
	Distichlis spicata	Salt grass
	Juncus effusus	Soft Rush
	Liquidambar styraciflua	Sweet Gum
	Luzula sp.	Wood Rush
	Mitchella repens	Partridge-berry
	Myrica pensylvanica	Bayberry
	Panicum virgatum	Switch grass
	Phragmites communis	Common reed
	Phytolacca americana	Pokeweed
	Polygonum pensylvanicum	Pennsylvania Smartweed
	Rubus sp.	Raspberry
	Spartina alterniflora	Saltmarsh Cordgrass
	Spartina patens	Saltmeadow Cordgrass
Ferns	*Dennstaedtia punctilobala*	Hay Scented Fern
	Onoclea sensibilis	Sensitive Fern
Trees	*Ilex opaca*	American Holly
	Pinus taeda	Loblolly Pine
	Platanus occidentalis	Sycamore
	Populus sp.	Aspen
	Prunus serotina	Black Cherry
	Quercus phellos	Willow Oak
Shrubs	*Aralia racemosa*	Hercules' club
	Iva frutescens	Marsh-elder

An approximately 5-foot high clay bank was observed in the areas of severe erosion along the northern shoreline. Adjacent to the eroding clay bank, a small, monotypic stand of common reed (*Phragmites australis*) persists. A meadow area of rushes and saltmeadow cordgrass (high marsh) exists south of the eroding northern bank, adjacent to the loblolly pine stands. Another high marsh habitat of saltmeadow cordgrass and salt grass exists along the southern area of the northern remnant and is continuous with a low marsh of saltmarsh cordgrass. A salt pan and a sandy beach are located adjacent to the marsh edges on the western area of the southern tip of the northern remnant. The northern island remnant is connected with the middle island remnant by a low marsh area (approximately 50 feet wide by 300 feet long) and a sand spit littered with relic oyster shells.

James Island Middle Remnant

The middle remnant of James Island consists of natural resources that include open water habitats, wetland habitats (both upper and lower marshes), upland forest habitats, and SAV. Because it is contiguous with the northern remnant (due to the spit), observed species were included in Table 3-12. The central portion of the middle remnant is composed of an upland habitat of thick loblolly pine saplings with a mature pine canopy and, moving southeast, a less thick loblolly pine canopy with a pocket of deciduous trees. A low marsh of saltmarsh cordgrass exists along the northern shore area of the middle remnant and a high marsh of saltmeadow cordgrass is congruent with the low marsh along the same shore. The southwestern shoreline is an eroded bare bank with remnants of the dominant high marsh shrub, marsh elder. An emergent marsh area of saltmarsh cordgrass, saltmeadow cordgrass, and marsh elder persists along the southern shore. The southern shoreline is a clay shelf and the water depth along this shoreline possessed abrupt drops. A large bed of SAV was observed along the eastern side of the sand spit that connects the middle and northern island remnants.

James Island Southern Remnant

The southern remnant of James Island consists of wetland habitats (both high and low marshes) and upland forest habitats. The species found are detailed on Table 3-13. The upland areas of the southern remnant are dominated by mature loblolly pines with a thick understory. Pockets of mixed deciduous trees, including willow oak, persimmon (*Diospyros virginiana*) and sycamore, occur within the loblolly pine stands. A remnant high marsh of saltmeadow cordgrass and burned loblolly pines persists along the northern area of southern remnant and a high marsh interspersed with saltgrass is located adjacent to the cove on the eastern shore. Bare and eroded shorelines with evidence of scorched pines by historic fires occur along the eastern and western shorelines and clay shelves range from one to four feet in height. The southernmost tip of the remnant supports a high marsh dominated by marsh elder.

TABLE 3-13. PLANT SPECIES OBSERVED ON THE SOUTHERN REMNANT OF JAMES ISLAND, FALL 2001 AND SUMMER 2002

Plant Group	Scientific Name	Common Name
Vines	*Toxicodendrun radicans*	Poison Ivy
Herbaceous plant	*Carex* sp.	Sedge species
	Distichlis spicata	Salt Grass
	Festuca sp.	Fescue
	Juncus roemerianus	Needlegrass Rush
	Phytolacca americana	Pokeweed
	Polygonum pensylvanica	Pennsylvania Smartweed
	Spartina patens	Saltmeadow Cordgrass
Trees	*Diospyros virginiana*	Persimmon
	Pinus taeda	Loblolly Pine
	Platanus occidentalis	Sycamore
	Quercus phellos	Willow Oak
Shrubs	*Iva frutescens*	Marsh-elder
	Myrica pensylvanica	Bayberry

3.2.2 Avian and Other Wildlife

A total of 42 species of birds were identified during visits to the James Island site in November 2001 and June 2002 (Table 3-14). The results of the timed bird observations are included in Table 3-15 (Figure 2-4). Several brown pelicans (*Pelecanus occidentalis*) were seen foraging in the waters adjacent to the remnants in June. It is likely these individuals are part of a small nesting population in the middle Chesapeake Bay. Double-crested cormorant (*Phalacrocorax auritus*), great blue heron (*Ardea herodias*) and green heron (*Butorides virescens*) were observed around the perimeter of the island remnants during the June surveys. Piscivorous species such as brown pelican, double-crested cormorant, green heron and great blue heron, were foraging for fish in the adjacent waters. Great blue heron was the only species of wader also observed in November and is probably a permanent resident in the vicinity of James Island. No evidence of colonial nesting for these three species was observed.

Wintering waterfowl utilized the waters surrounding the James Island remnants as evidenced by seven species of waterfowl observed in November. In June, only resident Canada geese (*Branta canadensis*) and mute swan (*Cygnus olor*) were observed. The tidal waters around James Island would provide food and shelter to wintering ducks and geese. Although not observed, the middle remnant could provide nesting habitat for the resident Canada geese and mute swan in the grassy upland area between the tidal marsh and the upland wooded area.

TABLE 3-14. CUMULATIVE LIST OF AVIAN SPECIES OBSERVED AT JAMES ISLAND, FALL 2001 AND SUMMER 2002

Common Name	Scientific Name	Date Observed		
		13 Nov 01	25 June 02	26 June 02
Brown Pelican	*Pelecanus occidentalis*		•	•
Double Crested Cormorant	*Phalacrocorax auritus*			•
Great Blue Heron	*Ardea herodias*	•	•	•
Great Egret	*Ardea alba*		•	
Green Heron	*Butorides virescens*		•	
Mute Swan	*Cygnus olor*		•	•
Canada Goose	*Branta canadensis*	•		•
Mallard	*Anas platyryhnchos*	•		
American Black Duck	*Anas rubripes*	•		
Canvasback	*Aythya valisineria*	•		
Greater Scaup	*Aythya marila*	•		
Long-tailed Duck	*Clangula hyemalis*	•		
Bufflehead	*Bucephala albeola*	•		
Northern Harrier	*Circus cyaneus*	•		
Bald Eagle	*Haliaeetus leucocephalus*	•	•	•
Osprey	*Pandion haliaetus*		•	•
Killdeer	*Charadrius vociferus*		•	
Dunlin	*Calidris alpina*	•		
Laughing Gull	*Larus atricilla*	•		•
Herring Gull	*Larus argentatus*	•		
Great Black-backed Gull	*Larus marinus*	•		•
Common Tern	*Sterna hirundo*			•
Forster's Tern	*Sterna forsteri*	•	•	•
Yellow-bellied Sapsucker	*Sphyrapicus varius*	•		
Great Crested Flycatcher	*Myiarchus crinitus*			•
Eastern Kingbird	*Tyrannus tyrannus*		•	•
American Crow	*Corvus brachyrhynchos*		•	•
Fish Crow	*Corvus ossifragus*	•		
Barn Swallow	*Hirundo rustica*		•	•
Tufted Titmouse	*Baeolophus bicolor*	•		
Carolina Chickadee	*Poecile carolinensis*	•	•	•
White-breasted Nuthatch	*Sitta carolinensis*	•		
Wren (family) species	Troglodytidae	•		
Carolina Wren	*Thryothorus ludovicianus*		•	•
Eastern Bluebird	*Sialia sialis*			•
Pine Warbler	*Dendroica pinus*		•	•

TABLE 3-14. (CONTINUED)

Common Name	Scientific Name	Date Observed		
		13 Nov 01	25 June 02	26 June 02
Northern Cardinal	*Cardinalis cardinalis*		•	•
Sparrow sp.	*Emberizidae*	•		
Dark-eyed Junco	*Junco hyemalis*	•		
Red-winged Blackbird	*Agelaius phoeniceus*	•	•	•
Common Grackle	*Quiscalus quiscula*		•	•
American Goldfinch	*Carduelis tristis*			•

TABLE 3-15. TOTAL NUMBER OF AVIAN SPECIES OBSERVED AT TIMED SURVEY SITES AT JAMES ISLAND, 25-26 JUNE 2002

Common Name	Scientific Name	Avian Station Location				
		B-1	B-2	B-3	B-4	B-5
Brown Pelican	*Pelecanus occidentalis*	3				
Great Blue Heron	*Ardea herodias*		1			
Great Egret	*Ardea alba*	1				
Mute Swan	*Cygnus olor*			2		
Bald Eagle	*Haliaeetus leucocephalus*	1		1		
Osprey	*Pandion haliaetus*	3	3	3		1
Laughing Gull	*Larus atricilla*				1	
Great Black-backed Gull	*Larus marinus*				1	
Common Tern	*Sterna hirundo*			1		
Forster's Tern	*Sterna forsteri*				2	
American Crow	*Corvus brachyrhynchos*	1	1			
Barn Swallow	*Hirundo rustica*			1		
Carolina Chickadee	*Poecile carolinensis*	1				
Eastern Bluebird	*Sialis sialis*			1		
Pine Warbler	*Dendroica pinus*	2				1
Northern Cardinal	*Cardinalis cardinalis*	1				
Red-winged Blackbird	*Agelaius phoeniceus*		1	3		
Common Grackle	*Quiscalus quiscula*		2	1		
TOTALS		**13**	**8**	**13**	**4**	**2**

One species of shorebird, the dunlin (*Calidris alpina*), was observed in November 2001 and one species of shorebird, the killdeer (*Charadrius vociferus*), was observed in June 2002. Although the low flat sandy beach area between the north and middle remnants of James Island provided excellent habitat for shorebirds only these two species were observed during the field surveys. Surveys in November would result in only those shorebird species that winter in the Chesapeake Bay region; dunlin is a common wintering shorebird in the Bay. In June, the surveys were conducted when migrating shorebirds have already passed through the area on their way to northern breeding grounds.

Raptors in the vicinity of James Island remnants in November included northern harrier (*Circus cyaneus*) and bald eagle (*Haliaeetus leucocephalus*). Bald eagles were also observed on site visits in June. Observations included an active bald eagle nest on the middle remnant containing an immature bird near fledging stage. In addition to the immature bird still in the nest, several adults and 1-2 other immature bald eagles were seen in June usually perched in loblolly pines, on dead snags or flying along the edges of all three remnants. One adult bald eagle was found dead on the southern remnant during the June site visit; the bird had been dead for a while and there was no observable indication of how it died. The bald eagle is a federal and Maryland State-listed threatened species. Osprey nests were seen offshore of the northern and southern remnants; one had been constructed on a duck blind; the other on a platform. Adult birds were observed flying back and forth to the nests. In one case an adult osprey was observed hunched in the nest mantling during the heat of the day. No immature birds were visible, but it is likely given the behavior of the adult that young were present in the nest.

Other species utilizing the open water habitats around the James Island remnants were three species of gulls and two species of terns. Similar to the brown pelican, double-crested cormorant and herons previously discussed, the gulls and terns utilized the adjacent waters offshore of James Island to forage for fish. No evidence of nesting on the island remnants was noted for any gull or tern species.

The upland area of the remnants provides habitat for a number of species to either spend the winter and/or breed. Wintering or late migrant species observed in November included yellow-bellied sapsucker (*Sphyrapicus varius*) and dark-eyed junco (*Junco hyemalis*). Birds using the upland habitat as summer resident/breeding species included great crested flycatcher (*Myiarchus crinitus*), eastern kingbird (*Tyrannus tyrannus*), and pine warbler (*Dendroica pinus*). Permanent residents of the upland area include Carolina chickadee (*Poecile carolinensis*), tufted titmouse (*Baeolophus bicolor*), white-breasted nuthatch (*Sitta carolinensis*), Carolina wren (*Thryothorus ludovicianus*), and northern cardinal (*Cardinalis cardinalis*). Several of these species were only observed during November however, species such as white-breasted nuthatch and tufted titmouse often become more secretive during and immediately after the nesting season.

Only a few species of birds were observed in the open marsh habitat. Eastern kingbird (*Tyrannus tyrannus*) and barn swallow (*Hirundo rustica*) foraged for insects over the open area; Common grackle (*Quiscalus quiscula*), red-winged blackbird (*Agelaius phoenicus*), and American goldfinch (*Carduelis tristis*) foraged among the shrubs and marsh grasses.

Some differences were noted in utilization of the area around the islands in the timed bird observations. The area off of the northern end of the northern remnant (associated with station B-5) was quite exposed and only 2 birds were observed utilizing it (Table 3-15). Similarly, the exposed shoreline along the western side of the southern remnant (Station B-4) supported few birds. The stations to the east of James Island (B-1 and B-2) as well as the cove and marsh near Station B-3 supported the most species during the timed observations. These areas provide protection from prevailing northwestern winds and habitat features such as emergent grasses and SAV that support a variety of bird species.

In addition to timed bird surveys, the site investigations of the James Island remnants also considered the potential use of the present habitats by other birds, mammals, reptiles and amphibians. Wildlife and wildlife sign (e.g., tracks, scat, bones, etc.) encountered were noted and are included in Table 3-16.

TABLE 3-16. WILDLIFE SPECIES OBSERVED AT JAMES ISLAND, SUMMER 2002

Common Name	Scientific Name
Invertebrates	
Horseshoe Crab	*Limulus polyphemus*
Blue Crab	*Callinectes sapidus*
Fiddler Crab	*Uca pugnax*
Fish	
Cownosed Ray	*Rhinoptera bonasus*
Croaker	*Micropogonias undulatus*
Reptiles	
Diamond-backed Terrapin	*Malaclemys terrapin*
Box Turtle	*Terrapene carolina*
Northern Brown Water Snake	*Nerodia sipedon*
Garter Snake	*Thamnophis sirtalis*
Mammals	
Raccoon	*Procyon lotor*
Sika Deer	*Cervus nippon*

Remnant (dead) horseshoe crabs (*Limulus polyphemus*) were found along the tide lines and low marsh areas of the remnants where waves had deposited them after their spring spawning. Fiddler crabs (*Uca pugnax*) were actively scuttling about in the salt pan and burrows in the clay banks of the lower marsh. Blue crabs (*Callinectes sapidus*) were noted in the SAV areas in the shallow waters around the remnants. Of the fish observed, numerous cownosed rays (*Rhinoptera bonasus*) were seen during both site visits in June foraging or swimming singly and in small groups in the shallow waters on both the east and west sides of the remnants. Croakers (*Micropogonias undulatus*) were also observed in the shallows. Several diamond-backed terrapin were noted and a dead northern water snake and garter snake were found along the shoreline during the habitat characterization visit in June 2002. Mammals (sika deer and raccoon) were identified by their tracks as seen in the sand and clay areas. Shells of ribbed mussel, American oyster, razor clams, and soft clams were also found along the beach (spit) in the Fall 2001 survey.

Except for the federally threatened bald eagle, no rare, threatened or endangered species were observed during the site visits.

3.2.3 Other Resources

The southern remnant of James Island showed evidence of the historic use of the island and possible archeological resources. The northern and middle remnants of James Island showed no evidence of historic or archeological resources. A shell midden is evident along the northeastern shore and pieces of brick and pottery were discovered along the southeastern shore of the southern remnant. In addition, ruins of a foundation for a home dwelling were observed on the southern island remnant.

3.3 Submerged Aquatic Vegetation (SAV) Mapping

Annual SAV data were downloaded from the VIMS website. The data included VIMS SAV mapping for the entire Bay interpreted from annual overflights. The period of record for this data was from 1971 to 2000 and resulted in 22 years of data; not all years were flown during the period of record. Data for 2001 and 2002 were not available at the time that this report was prepared. The available data were superimposed on maps of the area and compared to the proposed alignments for the James Island restoration project. Mapping of the existing VIMS SAV overflight data in the vicinity of James Island revealed that SAV was apparent adjacent to the island remnants in six years. The six years included 1989, 1990, 1991, 1992, 1993, and 1999. The data from these years have been downloaded, printed, and are presented as Figures E-1 through E-6 (Appendix E). Table 3-16 summarizes the areas of SAV of the beds immediately adjacent to James Island from 1971 to 2000. In addition to the acreages, the outside perimeter of the beds has been calculated in an attempt to estimate the summer flounder foraging habitat area. SAV covered an area of one to 18 acres in the years it was present, with perimeter (fringe habitat) lengths of 776.5 to 4,803.8 feet. The acreages reflected in Table 3-17 are for total SAV distributions in the area, however, no SAV has occurred within any of the proposed dike alignments since 1971.

In addition to the mapping effort, EA scientists mapped the existing areas of SAV adjacent to James Island during June 2002 field surveys (as discussed in Section 2.3). The areas of SAV are mapped on Figure 2-4 and were among the habitats used to select the seine and bird observation stations. Widgeon grass was the dominant SAV species identified in the beds and three individual areas of widgeon grass were located along the eastern shoreline of the island remnants. The SAV beds ranged from 100 to 150 yards from the eastern shoreline of the northern, middle, and southern remnants. In addition, small pockets of sea lettuce, which is considered a macroalgae and not a true SAV, were located in one of the beds of widgeon grass. The SAV mapping was a qualitative survey and therefore total SAV bed acreages were not generated at the feasibility-level of this study.

TABLE 3-17. EXTENT OF HISTORICAL SUBMERGED AQUATIC VEGETATION (SAV) IN THE VICINITY OF JAMES ISLAND AS DETERMINED BY VIRGINIA INSTITUTE OF MARINE SCIENCES (VIMS)

Year of SAV Survey	Acres of SAV*	Perimeter (ft) of SAV*
1971	0.0	0.0
1972	Area not flown during this year	
1973	Area not flown during this year	
1974	0.0	0.0
1975	Area not flown during this year	
1976	Area not flown during this year	
1977	Area not flown during this year	
1978	0.0	0.0
1979	0.0	0.0
1980	0.0	0.0
1981	0.0	0.0
1982	Area not flown during this year	
1983	Area not flown during this year	
1984	0.0	0.0
1985	0.0	0.0
1986	0.0	0.0
1987	0.0	0.0
1988	Area not flown during this year	
1989	1.0	776.5
1990	12.1	4198.0
1991	5.6	3414.4
1992	10.0	3633.6
1993	12.1	2834.9
1994	0.0	0.0
1995	0.0	0.0
1996	0.0	0.0
1997	0.0	0.0
1998	0.0	0.0
1999	18.1	4803.8
2000	0.0	0.0
2001	Data not available	
2002	Data not available	

*0.0 = no viable SAV observed in vicinity of James Island

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

James Island currently consists of three eroding island remnants. The northern two remnants are joined by a sand beach/spit that terminates in high-low marsh complexes on each end. Mixed forest stands of loblolly pine dominate the interior of the islands. Small remnants of high marsh can be found on all three remnants and the southern remnant has a fairly extensive marsh complex in the center. There was evidence of a fairly recent fire that killed many trees and impacted some of the marsh areas. The northern and western shorelines of each remnant show the heaviest erosion and there are many downed trees in the water in these areas.

Avian utilization of the island was typical for this area of the Bay, although total numbers of species for Summer 2002 were low relative to expectations and the survey may have missed the period of abundance during the spring migration. No large bird colonies (e.g. gulls, egrets, pelican, etc.) were found on the island. The island provides nesting habitat for a variety of song birds and raptors; 42 avian species were observed utilizing the vicinity in some capacity during the Fall 2001 and Summer 2002 surveys. There was also evidence that sika deer, raccoon, diamondback terrapin, and several snake species are also utilizing the island remnants.

The island remnants currently support SAV growth along their eastern shorelines. It is a monotypic bed of widgeon grass. Fisheries investigations of the shorelines indicated that remnants support a fairly diverse fish community, including juveniles of commercially important species. All species were typical of the region. There were no differences in the number of fish species collected inside and outside of the SAV beds in Summer 2002. Trawling yielded few species. This is likely due to a lack of habitat features outside of the shorezone of the island and most fish utilizing the area trawled are probably transients to the study area.

Ichthyoplantkton was sampled during the Summer 2002 collection, and densities were relatively high, dominated by bay anchovy. Zooplankton were typical of the region. Benthic samples were collected during both the Fall 2001 and Summer 2002 surveys. In general, the benthic community was typical of this area of the Bay and was dominated by a single species (gem clam) at most stations. The majority of the species found were stress-tolerant, resulting in low B-IBI scores at most locations in both Fall 2001 and Summer 2002. Although *in situ* water quality was typical for the region, lower than normal precipitation could have been affecting benthic distributions in the area in Summer 2002.

Results of the physical analyses indicated that the sediment around James Island was predominately comprised of sand (97.5-98.8%) at all sample stations except JAM-010, which was predominately comprised of silt-clay (82.8%). Of the five James Island sediment samples, location JAM-007 had the highest proportion of sand (98.9 %), although both stations JAM-002 and JAM-005 also had high proportions of sand (98.4%).

Of the 155 chemical constituents tested in the sediment, 57 were detected in James Island sediments. The majority of these detected constituents were found in low concentrations, and were representative of background concentrations. SVOCs, VOCs, and organophosphorus pesticides were not detected in any of the sediment samples. One PAH, acenaphthylene, exceeded the TEL value at sampling location JAM-002 by a factor of approximately 2.6 but did not exceed PEL values. None of the other detected chemical constituents exceeded TEL values.

4.2 Recommendations

Based upon the current studies and consultations with the Baltimore District USACE and NMFS, recommendations for future studies are included below.

- *In situ* sediment quality results and analyses indicate that there is very low possibility for potential effects to biota and therefore, no further sediment quality investigations are needed at the feasibility-level of this study.

- Fisheries studies would benefit from addition of gillnet collections to capture the transient species in the areas outside of the shore-zone. Therefore, it is recommended that fisheries studies be conducted during four seasons. All other fisheries and plankton sampling should be conducted as a quarterly collection effort since these resources change significantly with season.

- Nutrient sampling and analysis are recommended to be conducted at all benthic locations.

- Benthic sampling is not required for Fall 2003 since data previously exists from a fall period. At a minimum, benthic sampling is recommended to be conducted again during the spring. Winter sampling would probably not yield results that differ significantly from fall sampling, so winter sampling is not recommended.

- Bird observations are recommended during all seasons because avian utilization of various habitats can change dramatically with season.

- Terrestrial and vegetation resources are recommended to be monitored for changes but additional in-depth studies are not recommended at the feasibility-level of study because the proposed project will not directly impact these resources.

- Quantitative SAV surveys are recommended to be conducted during the spring and summer.

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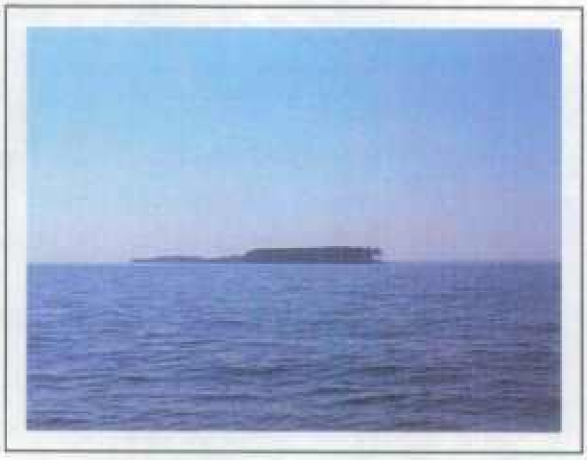
Appendix A:

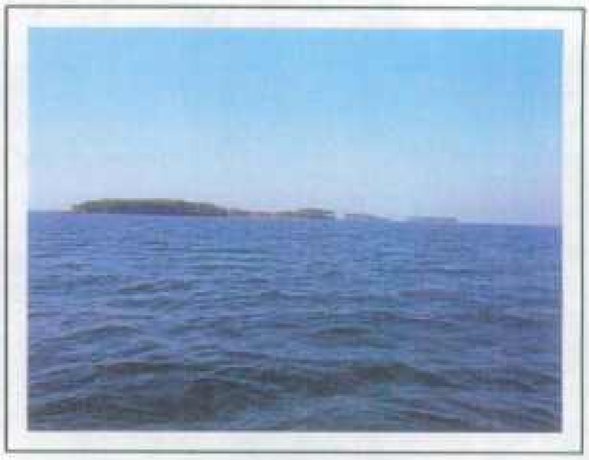
Photographic Records From Fall 2001 and Summer 2002 Surveys

Photographic Record

James Island
Chesapeake Bay, MD
Fall 2001



Looking southwest at James Island from station JAM-009.

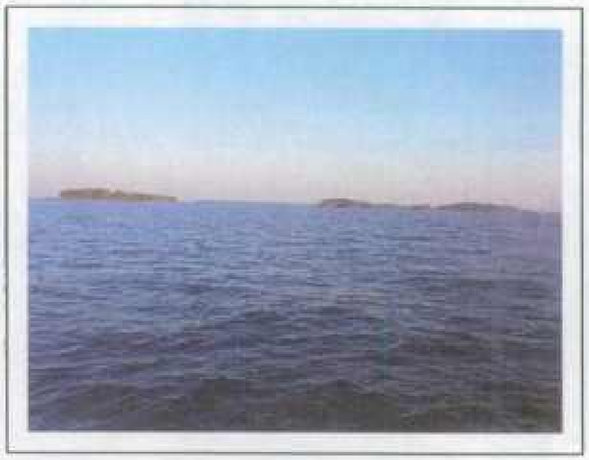


Looking northeast at James Island from station JAM-004.

Benthic collection effort at station JAM-004.

Sediment collection effort at station JAM-010.

Sediment collection effort from station JAM-003.



Looking east at James Island from JAM-005.

EA Engineering, Science, and Technology, Inc.

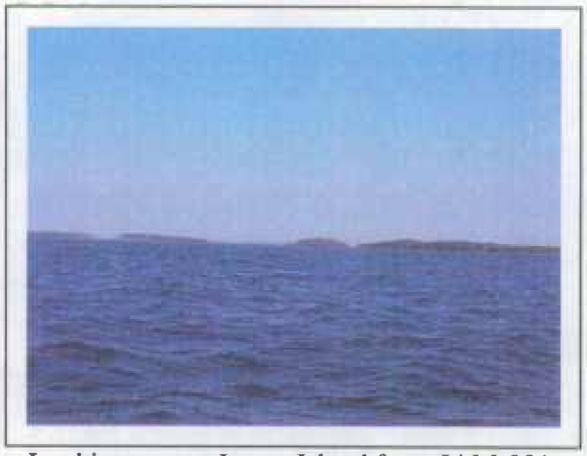
Photographic Record

James Island
Chesapeake Bay, MD
Fall 2001

Looking southeast at James Island from JAM-007.

Sediment collection effort at station JAM-007.

Looking southeast at James Island from JAM-006.



Looking east at James Island from JAM-001.

Looking west at the northern remnant of James Island.

Spartina marsh at north end of southern remnant.

Photographic Record

James Island
Chesapeake Bay, MD
Fall 2001

Western facing shoreline, looking northwest.

Western facing shoreline looking south.

Western-facing shoreline looking to the south.

Looking north at the sand spit that connects the middle and northern remnant.

Looking south at the middle remnant from sand spit.

Looking at the eastern side of the northern remnant.

Photographic Record

James Island
Chesapeake Bay, MD
Fall 2001

Looking north at the northwestern shoreline of the middle remnant.

Looking south at the southwestern shoreline of the middle remnant.

Looking south at the eastern shoreline of the southern remnant.

Looking south at the marsh at the south end of the northern remnant.

Looking south at the shoreline of the southern remnant.

The western shoreline of the southern remnant.

Photographic Record

James Island
Chesapeake Bay, MD
Fall 2001

Inundated marsh on middle remnant.

Raccoon, opossum and sika deer tracks.

Forested area on western side of southern remnant.

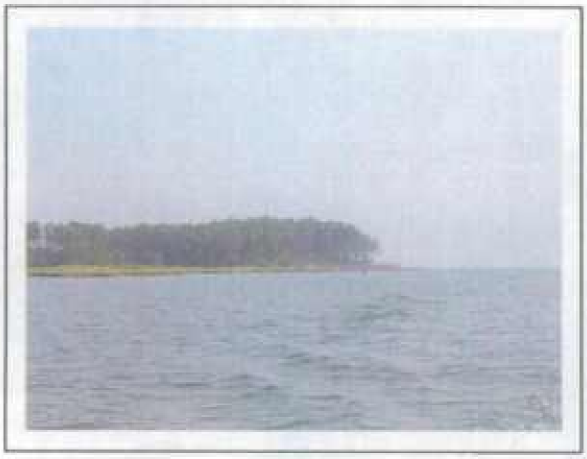
Eastern facing shoreline of middle remnant.

Looking at the northern remnant from the sand spit.

Erosion on the western facing shoreline.

Photographic Record

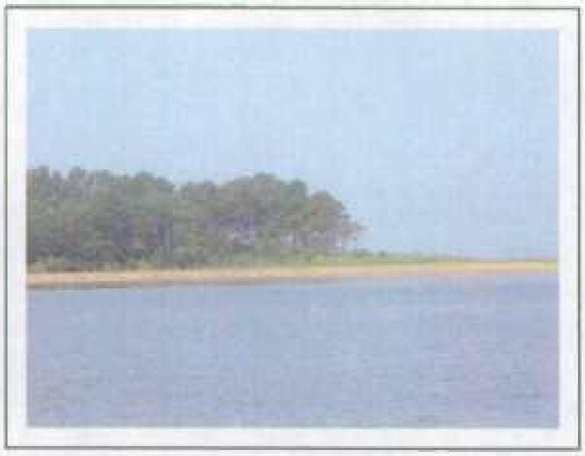
James Island
Chesapeake Bay, MD
Summer 2002



Eastern side of northern remnant of James Island.

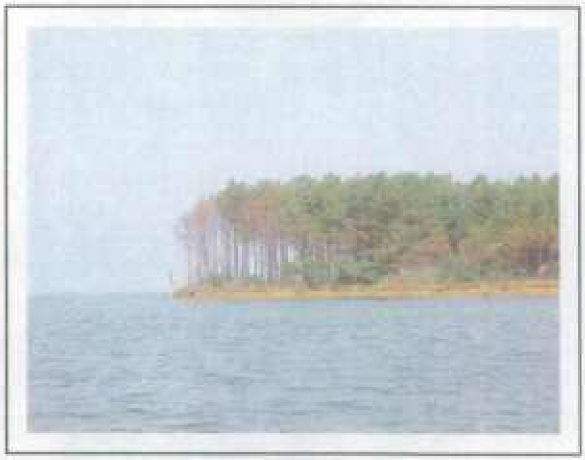
Eastern side of northern remnant of James Island.

Eastern side of northern remnant of James Island.



Eastern side of northern remnant of James Island.

Eastern side of northern remnant of James Island.

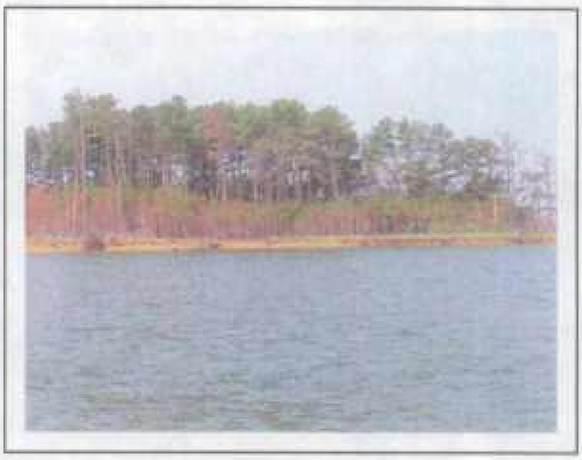


Eastern side of northern remnant of James Island.

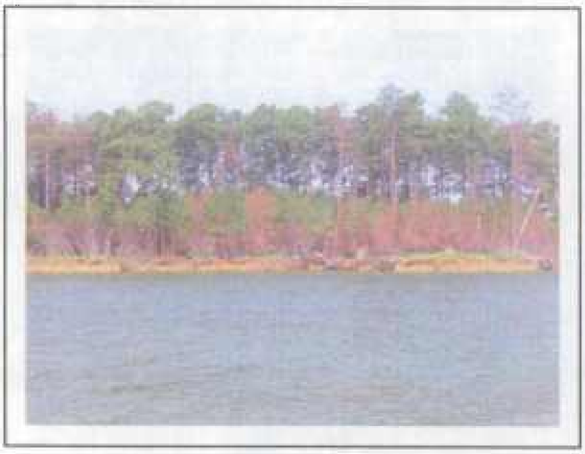
Photographic Record

James Island
Chesapeake Bay, MD
Summer 2002

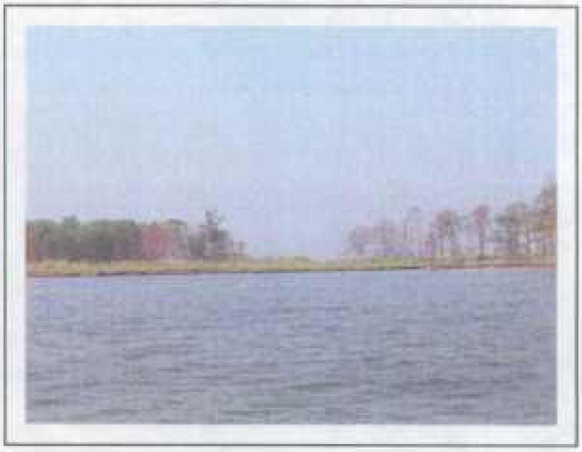
Southern tip of northern remnant of James Island on the eastern side.



Northern tip of southern remnant of James Island on the eastern side of the island.

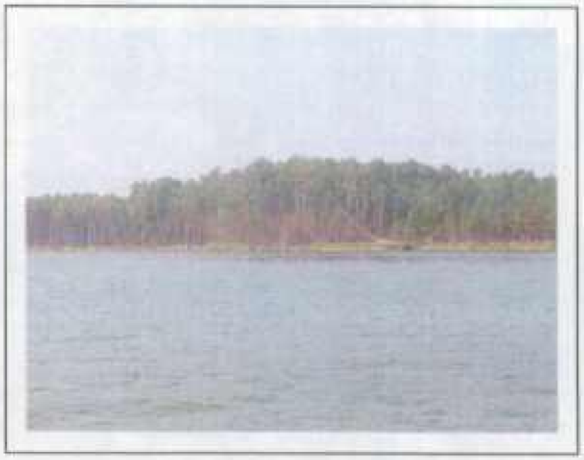


Southern remnant of James Island on the eastern side of the island.



Southern remnant of James Island on the eastern side of the island.

Southern remnant of James Island on the eastern side of the island.



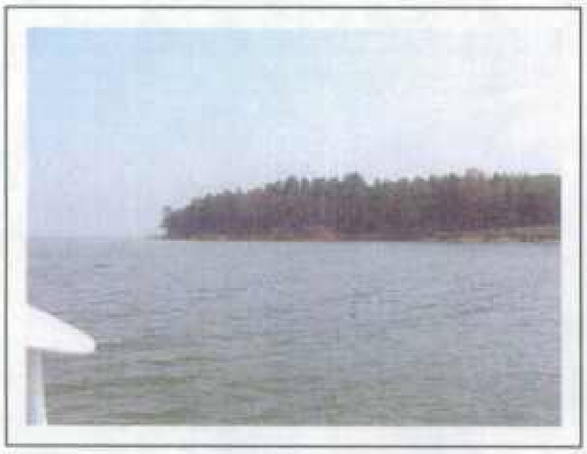
Southern remnant of James Island on the eastern side of the island.

Photographic Record

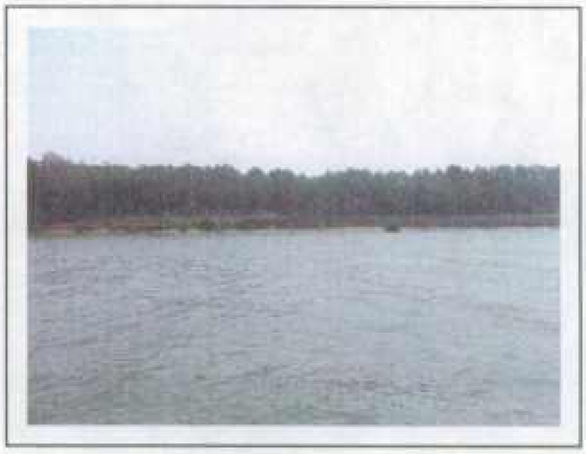
James Island
Chesapeake Bay, MD
Summer 2002

Southern remnant of James Island on the eastern side of the island.

Southern tip of the southern remnant of James Island



Southern tip of the southern remnant of James Island.



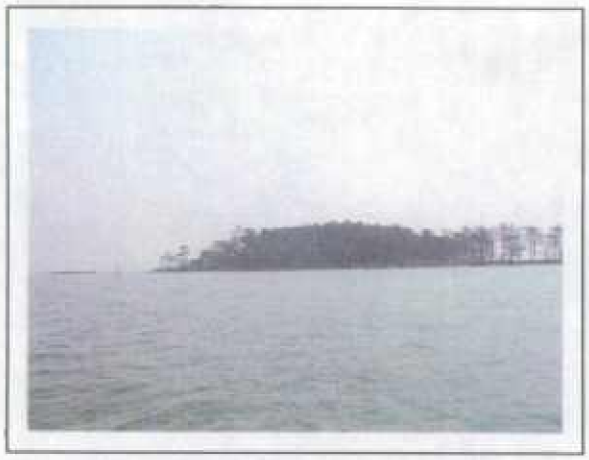
Southern tip of the southern remnant of James Island.

Southern remnant of James Island on the western side of the island.

Southern remnant of James Island on the western side of the island.

Photographic Record

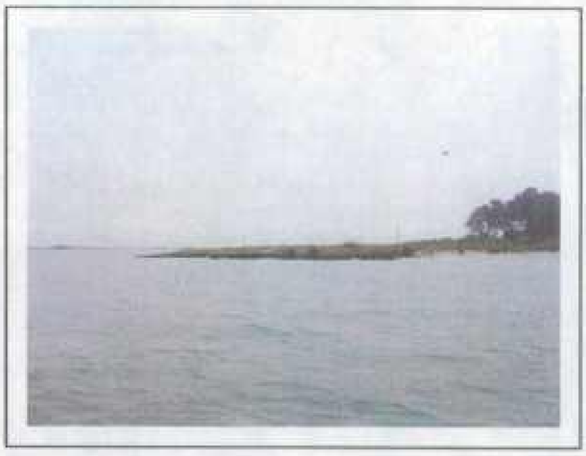
James Island
Chesapeake Bay, MD
Summer 2002



Southern remnant of James Island on the northern tip of the western side.

Northern remnant of James Island of the southern tip on the western side.

Northern remnant of James Island on the western side of the island.



Northern remnant of James Island on the western side of the island.

Northern remnant of James Island on the western side of the cove.

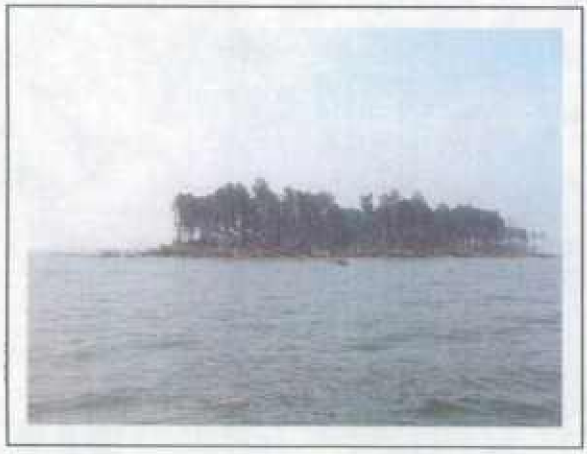
Northern remnant of James Island on the western side of the cove.

Photographic Record

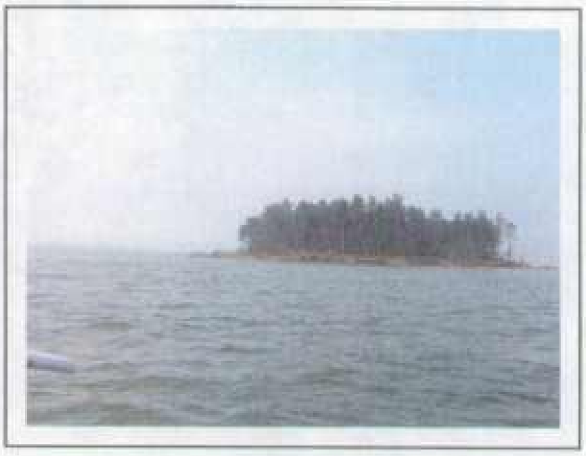
James Island
Chesapeake Bay, MD
Summer 2002

Northern remnant of James Island on the western side of the cove.

Northern remnant of James Island on the western side of the cove.



North remnant of James Island on the northern tip of the island.



Northern remnant of James Island on the northern tip of the island.

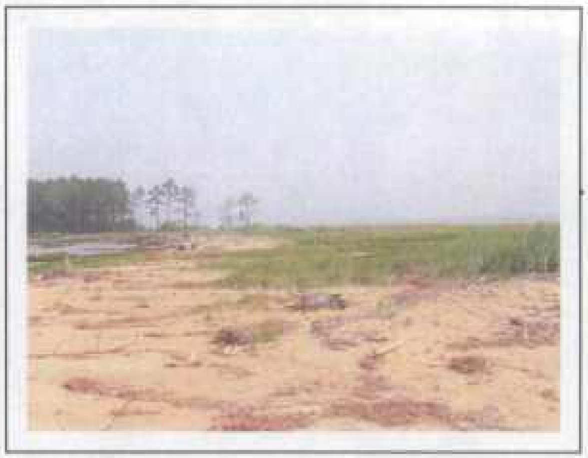
Northern remnant of James Island on the eastern side of the island.

Northern remnant of James Island on the eastern side of the island.

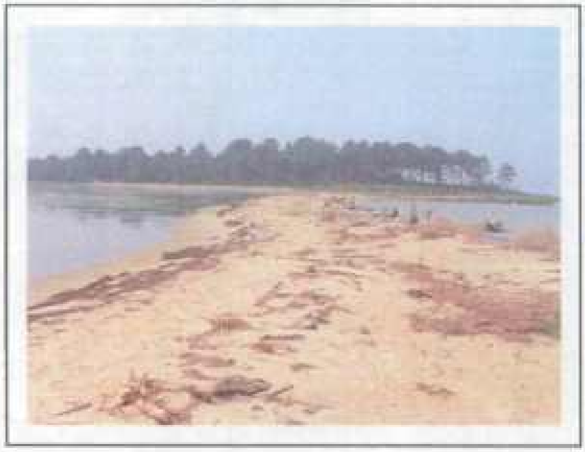
Photographic Record

James Island
Chesapeake Bay, MD
Summer 2002

Northern remnant of James Island on the eastern side of the island.



Marsh on the northern remnant of James Island.



Sand spit on northern remnant of James Island.

SAV in cove on the eastern side of the northern remnant

Open water on the northern remnant of James Island.

Loblolly pine stand in the central portion of the northern remnant.

EA Engineering, Science, and Technology, Inc.

Photographic Record

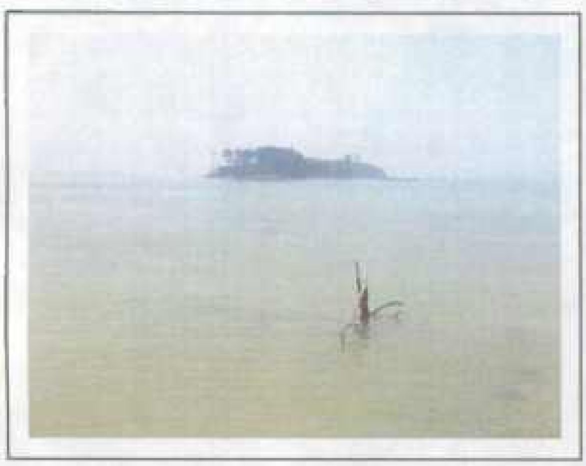
James Island
Chesapeake Bay, MD
Summer 2002

Bald eagle in nest on southern end of northern remnant of James Island.

Bald eagle in nest on southern end of northern remnant of James Island.

Bald eagle feathers found on the southern end of the northern remnant of James Island.

Southern shoreline of northern remnant of James Island.



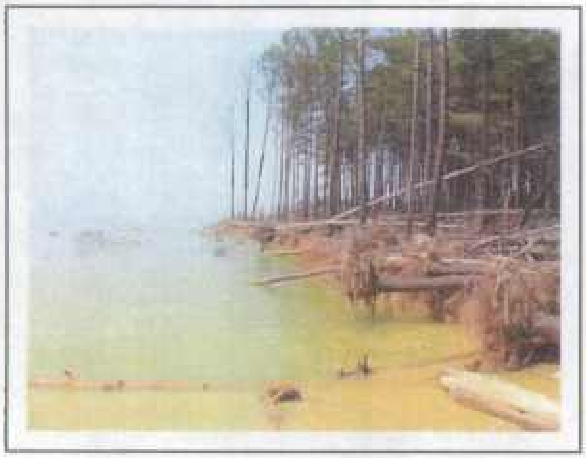
Northern tip of the southern remnant of James Island from the northern remnant.

Workboat off of the northern remnant shoreline of James Island.

EA Engineering, Science, and Technology, Inc.

Photographic Record

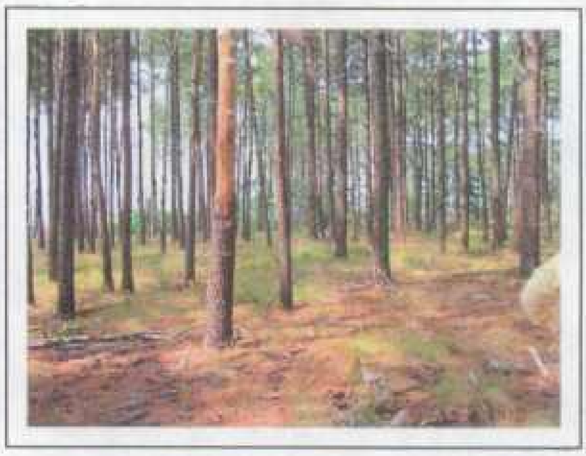
James Island
Chesapeake Bay, MD
Summer 2002



Northwest shoreline of the northern remnant of James Island.

Northwest shoreline of the northern remnant of James Island.

Northwest shoreline of the northern remnant of James Island.



Looking to the north at a loblolly pine stand in the northern end of the northern remnant.

Looking south at thick loblolly pine saplings at the northern end of the northern remnant.

Scorched pine trunks at the northern end of the northern remnant.

Photographic Record

James Island
Chesapeake Bay, MD
Summer 2002

The northern tip of the southern remnant of James Island.

Scorched pine trunks from fairly recent fires.

Small cove with eroded bank on north tip of southern remnant of James Island.

Small cove with eroded bank on north tip of southern remnant of James Island.

Emergent *Spartina* marsh located on north end of southern remnant of James Island.

Emergent marsh looking north at the southern remnant of James Island.

Photographic Record

James Island
Chesapeake Bay, MD
Summer 2002

Burned under-story at the southern remnant of James Island.

Dead eagle on ground on the southern remnant of James Island.

Northern, middle, and southern remnants of James Island.

Looking north from sand spit between northern and middle remnants.

Sand spit and marsh between north and middle remnants of James Island.

Northern remnant of James Island.

Appendix B:

Differential Global Positioning System (DGPS) Coordinates for Fall 2001 and Summer 2002 Aquatic Surveys

TABLE B-1. DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS) COORDINATES FOR BENTHIC COLLECTIONS AT JAMES ISLAND, FALL 2001

Benthic Station Number	Coordinates (NAD83)	
	Northing	Easting
JAM-001	303428.405	1495676.313
JAM-002	306841.230	1496022.495
JAM-003	303737.612	1499790.808
JAM-004	303765.510	1503056.752
JAM-005	310215.480	1498532.696
JAM-006	317143.280	1494435.375
JAM-007	317282.214	1496775.516
JAM-008	315868.251	1499520.410
JAM-009	316127.302	1504239.179
JAM-010	310916.952	1503678.259

TABLE B-2. DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS) COORDINATES FOR BENTHIC COLLECTIONS AT JAMES ISLAND, SUMMER 2002

Benthic Station Number	**Coordinates (NAD83)**	
	Northing	**Easting**
JAM-001	303428.41	1495676.31
JAM-002	306841.23	1496022.50
JAM-003	303737.61	1499790.81
JAM-004	303765.51	1503056.75
JAM-005	310215.48	1498532.70
JAM-006	317143.28	1494435.38
JAM-007	317282.21	1496775.52
JAM-008	315868.25	1495520.41
JAM-009	316127.30	1504239.18
JAM-010	310916.95	1503678.26

TABLE B-3. DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS) COORDINATES FOR FISH AND PLANKTON TRAWL COLLECTIONS AT JAMES ISLAND, SUMMER 2002

Station Number	Start Coordinate (NAD83)		End Coordinate (NAD83)	
	Northing	Easting	Northing	Easting
Fish Trawl[1]				
JF001A	314531.52	1503956.22	315936.21	1502909.94
JF001B	314350.18	1503726.26	315460.12	1502582.95
JF002A	310550.13	1504844.80	309007.77	1504468.80
JF002B	310473.65	1504580.35	308973.25	1504221.98
JF003A	302700.33	1502275.72	304504.29	1503156.86
JF003B	302753.01	1502572.04	304137.61	1503610.96
JF004A	308083.61	1499924.79	309779.77	1499913.65
JF004B	307582.70	1499648.57	309796.41	1499311.83
JF005A	311957.93	1496386.46	313924.88	1496454.81
JF005B	312130.22	1497467.44	313496.91	1497517.06
JF006A	311618.51	1499972.92	313319.96	1500414.72
JF006B	311583.32	1500302.10	312919.60	1500237.51
Plankton Trawl[2]				
JP001S/B	314736.83	1503832.69	315306.19	1502767.03
JP002S/B	309307.54	1504800.20	310688.53	1505072.31
JP003S/B	304608.83	1502909.78	302800.24	1502202.12
JP004S/B	307942.21	1499779.62	306486.33	1499804.78
JP005S/B	313413.95	1496946.16	312012.84	1496965.86
JP006S/B	313194.16	1500039.12	311572.34	1499875.87

[1] A = Initial trawl; B = Second trawl parallel with initial trawl
[2] S/B = Surface and bottom trawls were collected concurrently

TABLE B-4. DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS) COORDINATES FOR SEINE COLLECTIONS AT JAMES ISLAND, SUMMER 2002

Seine Station Number	Coordinates (NAD83)	
	Northing	Easting
Seine Site #1	310699.01	1502554.35
Seine Site #2	310354.60	1502316.03
Seine Site #3	307118.80	1502001.39
Seine Site #4	309580.91	1502035.13

Appendix C:

Benthic Macroinvertebrate and Fisheries Results

TABLE C-1. TAXONOMIC LIST OF BENTHIC MACROINVERTEBRATES COLLECTED WITH A PONAR FROM JAMES ISLAND, OCTOBER 2001 AND JUNE 2002[(a)]

CNIDARIA (sea anemones)
- *Edwardsia elegans*

PLATYHELMINTHES (flatworms)
- Planariidae[(b)]
- *Stylochus ellipticus*[(b)] (oyster flatworm)
- *Turbellaria sp. A*[(b)]

NEMERINEA (unsegmented worms)
- Nemertinea
- Amphiporidae sp.
- *Amphiporus bioculatus*
- *Micrura leidyi* (red ribbon worm)
- *Carinoma tremaphorus*

GASTROPDA (snails)
- *Acteocina canaliculata* (barrel bubble snail)
- *Sayella chesapeakea*
- *Haminoea solitaria* (solitary bubble snail)
- *Boonea impressa*[(b)]
- *Hydrobia truncata*

BIVALVIA (clams and mussels)
- *Gemma gemma* (gem clam)
- *Macoma mitchelli*
- *Macoma balthica* (baltic clam)
- *Petricola pholadiformis* (false angel wing)
- *Mulinia lateralis* (coot clam)
- *Mya arenaria*
- *Tagelus divisus*

ANNELIDA (segmented worms)
- POLYCHAETA (bristle worms)
  - *Glycinde solitaria* (chevron worm)
  - *Heteromastus filiformis* (capitellid thread worm)
  - *Polydora cornuta* (mud worm)
  - *Polydora websteri*[(b)] (oyster mud worm)
  - *Neanthes succinea*
  - *Pectinaria gouldii* (trumpet worm)
  - *Eteone heteropoda* (freckled paddle worm)
  - *Eteone foliosa*
  - *Glycera dibranchiata*

(a) Common names taken from Chesapeake Bay Program (CBP) (CBP 1992).
(b) Species not rated or assigned feeding guild or life history groupings for B-IBI (ICPRB 1999 and Ranasinghe et al. 1993).

TABLE C-1. (CONTINUED)

Streblospio benedicti (barred-gilled mud worm)
Marenzellaria viridis
Mediomastus ambiseta
Leitoscoloplos spp.
Leitoscoloplos robustus
Scolelepis (Parascolelepis) texana
Podarkeopsis levifuscina
Paraprionospio pinnata (fringe-grilled mud worm)
Paraonis fulgens
Tharyx sp. A Scolelepis (Parascolelepis) texana

OLIGOCHAETA (aquatic worms)
Tubificoides spp.

CRUSTACEA
AMPHIPODA (beach fleas; scuds)
Apocorophium lacustre
Ampelisca abdita (four-eyed amphipod)
Ameroculodes spp. complex
Cymadusa compta
Incisocalliope aestuarius
Leptocheirus plumulosus
Microprotopus raneyi[b]
Mucrogammarus mucronatus
ISOPODA (isopods)
Edotea triloba [b] (mounded-back isopod)
Chiridotea coceca
Cyathura polita (slender isopod)
Paracereis caudata[b] (eelgrass pill bug)
BRACHYURA (true crabs)
Callinectes sapidus
CARIDEA (caridean shrimp)
Crangon septemspinosa
CUMACEA (cumacean shrimp)
Oxyurostylis smithi
BRANCHIURAN (barnacles)
Balanus improvisus[b] (bay barnacle)
MYSIDAE (mysid shrimp)
Neomysis americana[b] (opposum shrimp)
Americamysis almyra[b]

PHORONIDA (horseshoe worms)
Phoronis sp.

UROCHORDATA (tunicates)
Molgula manhattensis[b] (sea grapes)

[a] Common names taken from Chesapeake Bay Program (CBP) (CBP 1992).
[b] Species not rated or assigned feeding guild or life history groupings for B-IBI (ICPRB 1999 and Ranasinghe et al. 1993).

TABLE C-2. MEAN DENSITIES (#/m^2) OF BENTHIC MACROINVERTEBRATES COLLECTED WITH A PONAR AT JAMES ISLAND, OCTOBER 2001

Taxon	Mean Density (#/m^2) by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010
PLATYHELMINTHES (flatworms)										
Planariidae [(a)]		14.3						6.1		
Stylochus ellipticus [(a)]	142.8	87.7	40.8		20.4	224.4	20.4	6.1	55.1	
NEMERTINEA (unsegmented worms)										
Amphiporus biocalatus	14.3				26.5	34.7		55.1	6.1	
Amphiporidae sp.				6.1						6.1
Carinoma tremaphorus				14.3						
Micrura leidyi (red ribbon worm)	14.3	20.4	14.3	6.1		6.1		20.4	20.4	
Nemertinea						6.1				
GASTROPDA (snails)										
Acteocina canaliculata (barrel bubble snail)	210.1	177.5	1,332.1	61.2	61.2	183.6	87.7	67.3	638.5	
Boonea impressa[(a)]				14.3						
Epitonium rupicola										
Gastropoda										
Haminoea solitaria (solitary bubble snail)	102.0	26.5	108.1			26.5		6.1	14.3	
Hydrobia truncata					87.7			67.3		299.9
Rictaxis punctostriatus										
Sayella chesapeakea			20.4	6.1						
BIVALVIA (clams and mussels)										
Gemma gemma (gem clam)	30,769.3	71,589.7	217,056.0	45,118.7	91,581.7	249,804.1	97,864.9	355,096.7	190,019.9	2,386.8
Lyonsia hyalina										
Macoma balthica				6.1						
Macoma mitchelli			14.3	14.3					20.4	
Mulinia lateralis (coot clam)	6.1	6.1	20.4	14.3	6.1	14.3			14.3	6.1
Mya arenaria										
Petricola pholadiformis				20.4						

(a) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999; Ranasinghe et al. 1993).

TABLE C-2. (CONTINUED)

Taxon	Mean Density (#/m^2) by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010
ANNELIDA (segmented worms)										
POLYCHAETA (bristle worms)										
Eteone foliosa							6.1			
Etone heteropoda (freckled paddle worm)	26.5	55.1	102.0	6.1	157.1	189.7	34.7	95.9	157.1	
Glycinde solitaria (chevron worm)	489.6	102.0	238.7	1,013.9	75.5	238.7	67.3	102.0	291.7	75.5
Heteromastus filiformis (capitellid thread worm)	116.3	46.9	148.9	626.3	55.1	26.5	108.1	75.5	148.9	177.5
Leitoscoloplos robustus				20.4						
Leitoscoloplos spp.	14.3			26.5		6.1		6.1	6.1	
Marenzellaria viridis									6.1	
Mediomastus ambiseta	20.4			463.1						
Neanthes succinea	55.1	34.7	20.4	1,066.9	136.7	189.7	67.3	81.6	265.2	1,217.9
Paraprionospio pinnata	6.1			14.3						
Pectinaria gouldii (trumpet worm)	75.5	26.5	6.1	20.4	20.4	34.7	6.1	34.7	40.8	
Podarkeopsis levifuscina	6.1					14.3		14.3		
Polydora cornuta				6.1				6.1		6.1
Polydora websteri[(a)]				6.1						
Scolelepis (Parascolelepis) texana			6.1							
Streblospio benedicti (barred-gilled mud worm)	6.1	6.1		55.1		6.1			6.1	20.4
OLIGOCHAETA (aquatic worms)							6.1			
Tubificoides spp.	6.1		6.1	320.3	40.8		6.1		6.1	6.1
CRUSTACEA										
AMPHIPODA (beach fleas; scuds)										
Microprotopus raneyi [(a)]					61.2	95.9		14.3	6.1	
Ameroculodes spp. Complex	20.4	6.1	6.1		20.4	14.3		67.3	26.5	6.1
Ampelisca abdita				67.3						
Apocorophium lacustre								6.1		

(a) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999; Ranasinghe et al. 1993).

TABLE C-2. (CONTINUED)

Taxon	Mean Density (#/m^2) by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010
ISOPODA (isopods)										
Paracereis caudata		6.1				169.3		163.2	6.1	
Edotea triloba (mounded-back isopod) [a]	6.1	20.4	6.1	34.7		14.3			14.3	40.8
Cyathura polita (slender isopod)									6.1	
CUMACEA (cumacean shrimp)										
Oxyurostylis smithi	34.7					6.1				
BRANCHIURAN (barnacles)										
Balanus improvisus (bay barnacle) [a]			6.1			14.3		14.3		6.1
MYSIDACEA (mysid shrimp)										
Americamysis almyra [a]									26.5	46.9
Neomysis americana [a]									20.4	
UROCHORDATA (tunicates)										
Molgula manhattensis [a]								6.1		
TOTALS	**32,142.2**	**72,226.2**	**219,153.1**	**49,029.4**	**92,350.8**	**251,319.8**	**98,275.0**	**356,012.6**	**191,823.2**	**4,302.4**

(a) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999; Ranasinghe et al. 1993).

TABLE C-3. MEAN DENSITIES (#/m^2) OF BENTHIC MACROINVERTEBRATES COLLECTED WITH A PONAR AT JAMES ISLAND, JUNE 2002

Taxon	Mean Density (#/m^2) by Station Number									
	JAM-001	**JAM-002**	**JAM-003**	**JAM-004**	**JAM-005**	**JAM-006**	**JAM-007**	**JAM-008**	**JAM-009**	**JAM-010**
CNIDARIA (sea anemones)										
Edwardsia elegans						6.12				
PLATYHELMINTHES (flatworms)										
Stylochus ellipticus [(a)]	61.2	14.28	20.4		6.12	136.68		26.52		
Turbellaria sp. A [(a)]		6.12			26.52	40.8				
NEMERTINEA (unsegmented worms)										
Amphiporus biocalatus		20.4	14.28		81.6	40.8		34.68	34.68	
Amphiporidae sp.						6.12		6.12		
Carinoma tremaphorus				14.28						
Micrura leidyi (red ribbon worm)				14.28	6.12	14.28		14.28		
Nemertinea								14.28		
GASTROPODA (snails)										
Acteocina canaliculata (barrel bubble snail)	524.28	87.72	285.6		102	142.8	14.28		224.4	
Haminoea solitaria (solitary bubble snail)		67.32	61.2		55.08	14.28			95.88	
Hydrobia truncata		6.12			142.8					6.12
Sayella chesapeakea	6.12				6.12					6.12
BIVALVIA (clams and mussels)										
Gemma gemma (gem clam)	296,263.1	144,988.9	212,486.4	127,759.1	220,564.8	347,099.9	138,705.7	203,347.2	219,340.8	41,793.5
Macoma mitchelli				6.12	6.12					
Mulinia lateralis (coot clam)				34.68					6.12	40.8
Mya arenaria				14.28						14.28
Tagelus divisus										6.12

(a) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999; Ranasinghe et al. 1993).

TABLE C-3. (CONTINUED)

Taxon	Mean Density (#/m^2) by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010
ANNELIDA (segmented worms)										
POLYCHAETA (bristle worms)										
Eteone foliosa					6.12	26.52		6.12	14.28	
Etone heteropoda (freckled paddle worm)	142.8	55.08	6.12	20.4	6.12	87.72	6.12	6.12		6.12
Glycera dibranchiata	6.12	6.12								
Glycinde solitaria (chevron worm)	67.32	40.8	20.4	469.2	75.48	6.12	6.12	46.92	95.88	40.8
Heteromastus filiformis (capitellid thread worm)	61.2	75.48	136.68	224.4	87.72	81.6	6.12	332.52	136.68	55.08
Leitoscoloplos robustus					6.12					
Leitoscoloplos spp.		20.4	6.12	46.92		6.12	6.12			
Marenzellaria viridis		6.12						6.12	6.12	
Mediomastus ambiseta				340.68						
Neanthes succinea	401.88	475.32	210.12	571.2	271.32	673.2	128.52	516.12	55.08	291.72
Paraonis fulgens			20.4							
Polydora cornuta	55.08	55.08	40.8	20.4	34.68	122.4		34.68		
Scolelepis (Parascolelepis) texana	6.12									
Streblospio benedicti (barred-gilled mud worm)	4012.68	1046.52	652.8	2998.8	95.88	1515.72	6.12	157.08	591.6	2890.68
Tharyx sp. A	20.4	14.28			6.12					
OLIGOCHAETA (aquatic worms)										
Oligochaeta		128.52				87.72		6.12	61.2	
Tubificoides spp.	6.12	6.12	1.428		6.12		14.28	55.08		
CRUSTACEA										
AMPHIPODA (beach fleas; scuds)										
Ameroculodes spp. complex	571.2	291.72	667.08	81.6	1075.08	516.12	46.92	340.68	346.8	128.52
Ampelisca abdita	122.4	26.52	20.4	679.32	40.8	20.4	6.12	95.88	128.52	401.88
Cymadusa compta					6.12					
Incisocalliope aestuarius										6.12
Leptocheirus plumulosus										6.12
Microprotopus raneyi [(a)]					14.28	6.12				
Mucrogammarus mucronatus	6.12	34.68			40.8	6.12		6.12	14.28	20.4

(a) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999; Ranasinghe et al. 1993).

TABLE C-3. (CONTINUED)

Taxon	Mean Density (#/m^2) by Station Number									
	JAM-001	JAM-002	JAM-003	JAM-004	JAM-005	JAM-006	JAM-007	JAM-008	JAM-009	JAM-010
ISOPODA (isopods)										
Chiridotea coeca	6.12									
Cyathura polita (slender isopod)			6.12							14.28
Edotea triloba (mounded-back isopod) [(a)]	148.92	55.08		102	6.12	34.68		14.28	14.28	61.2
Paracereis caudata						20.4	6.12	20.4		
BRACHYURA (true crabs)										
Callinectes sapidus				6.12						
CARIDEA (caridean shrimp)										
Crangon septemspinosa			6.12							
CUMACEA (cumacean shrimp)										
Oxyurostylis smithi	67.32	6.12	14.28		20.4					14.28
BRANCHIURAN (barnacles)										
Balanus improvisus (bay barnacle) [(a)]	244.8	40.8	61.2	55.08	46.92	422.28	55.08	20.4	128.52	14.28
MYSIDACEA (mysid shrimp)										
Neomysis americana [(a)]	136.68	597.72	210.12	14.28	14.28	6.12		6.12		87.72
PHORONIDA										
Phoronis sp.	6.12									
TOTAL	**302,944.1**	**148,173.4**	**214,948.1**	**133,473.1**	**222,857.8**	**351,141.1**	**139,007.6**	**205,113.8**	**221,295.1**	**45,906.1**

(a) Species not meeting B-IBI macrofaunal criteria (ICPRB 1999; Ranasinghe et al. 1993).

TABLE C-4. FISHES AND CRABS COLLECTED DURING FISHERIES STUDIES NEAR JAMES ISLAND, JUNE 2002

Common Name		Scientific Name	
Family	**Species**	**Family**	**Species**
Herrings	Blueback herring	Clupeidae	*Alosa aestivalis*
	Atlantic menhaden		*Brevoortia tyrannus*
Anchovies	Bay anchovy	Engraulidae	*Anchoa mitchilli*
Clingfishes	Skilletfish	Gobiesocidae	*Gobiesox strumosus*
Flyingfishes	Halfbeak	Exocoetidae	*Hyporhamphus unifasiatus*
Needlefishes	Atlantic needlefish	Belonidae	*Strongylura marina*
Killifish	Sheepshead minnow	Cyprinodontidae	*Cyprinodon variegatus*
	Mummichog		*Fundulus heteroclitus*
	Rainwater killifish		*Lucania parva*
Silversides	Atlantic silverside	Atherinidae	*Menidia menidia*
Pipefishes	Northern pipefish	Syngnathidae	*Sygnathus fuscus*
Temperate basses	Striped bass	Moronidae	*Morone saxatilus*
Drums	Atlantic croaker	Sciaenidae	*Micropogonias undulatus*
	Red drum		*Sciaenops ocellatus*
	Spot		*Leiostomus xanthurus*
Gobies	Naked goby	Gobiidae	*Gobiosoma bosci*
Lefteye flounders	Summer flounder	Bothidae	*Paralichthys dentatus*
Soles	Hogchoker	Soleidae	*Trinectes maculatus*
Tonguefishes	Blackcheek tonguefish	Cynoglossidae	*Symphurus plagiusa*
Swimming crabs	Blue crab	Portunidae	*Callinectes sapidus*

TABLE C-5. SUMMARY OF MEAN TOTAL LENGTH (mm) AND RANGE (mm) OF MEASUREMENTS FOR JAMES ISLAND FISH COLLECTIONS, JUNE 2002

Species	Mean and Range	Mean Length (mm) and Range (mm) For Otter Trawl Stations						Mean Length (mm) and Range (mm) for Seine Stations			
		JF-001	JF-002	JF-003	JF-004	JF-005	JF-006	Seine #1	Seine #2	Seine #3	Seine#4
Atlantic Menhaden	Mean							47	47	42	
	Range							(35-61)	---	---	
Blueback Herring	Mean							34	37	36	
	Range							(31-36)	---	(33-41)	
Bay Anchovy	Mean			76				65	47		
	Range			(70-88)				(52-76)	---		
Skilletfish	Mean							26	28	21	44
	Range							(25-26)	(25-32)	(10-29)	(29-59)
Halfbeak	Mean							178			
	Range							---			
Atlantic Needlefish	Mean							133	124		129
	Range							(76-161)	(120-131)		(122-136)
Mummichog	Mean							46		47	
	Range							(34-86)		(26-86)	
Rainwater Killifish	Mean								34	39	
	Range								---	(35-43)	
Atlantic Silverside	Mean						54	65	95	57	87
	Range						---	(17-129)	(42-132)	(46-136)	(39-138)
Northern Pipefish	Mean			70				67	105	162	
	Range			---				(40-89)	(91-125)	---	
Striped Bass	Mean										160
	Range										---
Atlantic Croaker	Mean								82		
	Range								---		

TABLE C-5. (CONTINUED)

Species	Mean and Range	Mean Length (mm) and Range (mm) For Otter Trawl Stations						Mean Length (mm) and Range (mm) for Seine Stations			
		JF-001	JF-002	JF-003	JF-004	JF-005	JF-006	Seine #1	Seine #2	Seine #3	Seine#4
Red Drum	Mean									169	
	Range									(168-169)	
Spot	Mean			225				71	83	80	82
	Range			(221-229)				(52-108)	(54-127)	(56-121)	(58-150)
Naked Gobie	Mean			33							39
	Range			(32-33)							---
Summer Flounder	Mean								104	97	
	Range								(99-109)	(84-107)	
Hogchoker	Mean								84		
	Range								(64-103)		
Blue Crab	Mean			101		138		66	44	32	41
	Range			(51-142)		(134-141)		(29-129)	(15-95)	(13-72)	(16-116)
Sheepshead Minnow	Mean							30			
	Range							(26-40)			
Blackcheek Tonguefish	Mean							75			
	Range							--			

Appendix D:

Sediment Quality Results

TABLE D-1. ORGANIC DATA QUALIFIERS

Qualifiers other than those listed below may be required to properly define the results. If used, they are given an alphabetic designation not already specified in this table or in a project/program document such as a Quality Assurance Project Plan or a contract Statement of Work. Each additional qualifier was fully described in the Analytical Narrative section of the laboratory report.

U Indicates a target compound was analyzed for but not detected. The sample Reporting Limit (RL) is corrected for dilution and, if a soil sample, for percent moisture, if reported on a dry weight basis.

J Indicates an estimated value. This qualifier is used under the following circumstances:

1) when estimating a concentration for tentatively identified compounds (TICs) in GC/MS analyses, where a 1:1 response is assumed,
2) when the mass spectral and retention time data indicate the presence of a compound that meets the volatile and semivolatile GC/MS identification criteria, and the result is less than the RL but greater than the method detection limit (MDL).

B This qualifier is used when the analyte is found in the associated method blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. For GC/MS analyses, this qualifier is used for a TIC, as well as, for a positively identified target compound.

E This qualifier identifies compounds whose concentrations exceed the calibration range of the instrument for that specific analysis.

D When applied, this qualifier identifies all compound concentrations reported from a secondary dilution analysis.

A This qualifier indicates that a TIC is a suspected aldol-condensation product.

N Indicates presumptive evidence of a compound. This qualifier is only used for GC/MS TICs, where the identification is based on a mass spectral library search. For generic characterization of a TIC, such as chlorinated hydrocarbon, the N qualifier is not used.

P When applied, this qualifier indicates a reported value from a GC analysis when there is greater than 25% difference for detected concentrations between the two GC columns.

TABLE D-2. INORGANIC DATA QUALIFIERS

C ***(Concentration) qualifiers:***

B	Reported value is less than the project-specified Reporting Limit (RL), but greater than the method-specified Instrument Detection Limit (IDL) or Method Detection Limit (MDL).
U	Analyte analyzed for but not detected (concentration is less than the method-specified Instrument Detection Limit (IDL) or Method Detection Limit (MDL).

Q ***(Quality control) qualifiers:***

E	Reported value is estimated because of presence of interference.
M	Duplicate injection precision not met.
N	Spiked sample recovery is not within control limits.
S	Reported value is determined by the method of standard additions (MSA).
W	Postdigestion spike for furnace Atomic Absorption Spectrophotometric (AAS) AAS analysis is out of control limits (85-115%) and sample absorbance is less than 50% of spike absorbance.
*	Duplicate analyses is not within control limits.
+	Correlation coefficient for MSA is less than 0.995.

M ***(Method) qualifiers:***

P	Inductively Coupled Plasma (ICP)
A	Flame AAS
F	Furnace AAS
CV	Cold Vapor AAS
AV	Automated Cold Vapor AAS
AS	Semiautomated Spectrophotometric
C	Manual Spectrophotometric
T	Titrimetric
NR	Analyte is not required to be determined.

TABLE D-3. DIOXIN AND FURAN DATA QUALIFIERS

A	Amount detected is less than the Method Calibration Limit.
E	Amount detected is over the Method Calibration Limit.
DPE	Denotes the presence of possible polychlorinated diphenylesters.
EDL	"Estimated Detection Limit"
EMPC	"Estimated Maximum Possible Concentration"
ppt	Parts-per-trillion (pg/g; ng/L)
Q	Indicated the presence of quantitative interferences. They generally result in an underestimation of the affected total homologue groups.
V	Recovery is lower than 40%. The data has been validated based upon a favorable signal-to-noise and detection limit.

TABLE D-4. PHYSICAL CHARACTERISTICS OF SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
COBBLES	%	--	0	0	0	0	0
GRAVEL	%	--	0	0.1	0	0.1	0
SAND	%	--	98.4	98.4	98.8	97.5	17.2
SILT	%	--	0.6	0	0.2	0.3	54.1
CLAY	%	--	1	1.5	1	2.1	28.7
SILT+CLAY	%	--	1.6	1.5	1.2	2.4	82.8
% MOISTURE	%	--	24.1	26.3	27	29.5	30.9
% SOLIDS	%	0	0	78.2	75.9	76.9	71.8
SPECIFIC GRAVITY	G/ML	--	2.65	2.66	2.67	2.67	2.72

MDL = method detection limit

TABLE D-5. NUTRIENTS AND GENERAL CHEMISTRY PARAMETERS IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	RL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
AMMONIA, as N	MG/KG	2.4	**2.4**	**11.1**	**25.9**	**28.4**	**27.8**
NITRATE/NITRITE, as N	MG/L	0.005	**0.005**	0.005 U	0.005 U	0.005 U	0.005 U
NITROGEN, TOTAL KJELDAHL	MG/KG	57.34	**57.34**	**297**	**379**	**533**	**830**
TOTAL ORGANIC CARBON	%	0.01	**0.013**	**0.136**	**1.1**	**0.326**	**0.447**
BIOCHEMICAL OXYGEN DEMAND	MG/KG	155.8	**155.8**	**318**	**753**	**529**	**543**
CHEMICAL OXYGEN DEMAND	MG/L	6.9	**6.9**	6.9 U	6.9 U	6.9 U	6.9 U
TOTAL CYANIDE	MG/KG	0.102	**0.102**	**0.15 B J**	**0.16 B J**	**0.39 B J**	**0.3 B J**
TOTAL PHOSPHORUS	MG/KG	12.92	**12.92**	**63.6**	**98.2**	**43.1**	**72.2**
TOTAL SULFIDE	MG/KG	0.768	**0.768**	**60**	**66.4**	**21.7**	**85.8**

NOTE: Shaded and bold values represent detected concentrations.

RL = reporting limit

B = value is less than reporting limit, but greater than instrument detection limit or method detection limit

J = value is estimated

U = not detected

TABLE D-6. METAL CONCENTRATIONS (MG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	TEL*	PEL*	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
ALUMINUM	MG/KG	--	--	1.58	**398**	**291**	**193**	**811**	**6840**
ANTIMONY	MG/KG	--	--	0.234	**0.28 B**	0.23 U	**0.37 B**	**2.2 N**	**0.3 B**
ARSENIC	MG/KG	7.24	41.6	0.312	**0.82 B**	**0.45 B**	**0.63 B**	**0.69 B**	**1.3**
BERYLLIUM	MG/KG	--	--	0.0322	**0.33 B**	**0.38 B**	**0.36 B**	**0.31 B**	**0.53**
CADMIUM	MG/KG	0.676	4.21	0.0498	0.049 U	0.05 U	0.05 U	0.049 U	0.051 U
CHROMIUM	MG/KG	52.3	160.4	0.0722	**1**	**0.81**	**0.85**	**1.6**	**8.3**
COBALT	MG/KG	--	--	0.077	**0.37 B**	**0.12 B**	**0.15 B**	**0.72 B**	**2.6 B**
COPPER	MG/KG	18.7	108.2	0.0712	**0.074 B**	**0.098 B**	0.071 U	**0.52 B**	**3.1**
IRON	MG/KG	--	--	3.26	**840**	**671**	**624**	**1320**	**8400**
LEAD	MG/KG	30.24	112.18	0.244	**1.2**	**0.53**	**0.64**	**1.3**	**7.3**
MANGANESE	MG/KG	--	--	0.0262	**10.4**	**9.1**	**5.7**	**21.5**	**40.4**
MERCURY	MG/KG	0.13	0.696	0.0118	0.011 U	0.012 U	0.012 U	0.012 U	**0.013 B**
NICKEL	MG/KG	15.9	42.8	0.224	**0.96 B**	**0.73 B**	**0.6 B**	**2 B**	**7.8**
SELENIUM	MG/KG	--	--	0.322	0.32 U	0.32 U	0.32 U	0.32 U	0.33 U
SILVER	MG/KG	0.73	1.77	0.078	0.076 U	0.078 U	0.078 U	0.078 U	0.08 U
THALLIUM	MG/KG	--	--	0.556	0.54 U	0.56 U	0.56 U	0.55 U	0.57 U
TIN	MG/KG	--	--	3.3	3.2 U	3.3 U	3.3 U	3.3 U	3.4 U
ZINC	MG/KG	124	271	0.262	**4.2**	**4.4**	**2.8**	**6**	**21.6**
AVS/SEM	--	--	--	--	23.88	21.49	22.17	12.7	4.48

**Source*: Buchman 1999

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

TEL = threshold effects level

PEL = probable effects level

B = value is less than reporting limit, but greater than instrument detection limit or method detection limit

U = not detected

TABLE D-7. PAH CONCENTRATIONS (UG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	TEL*	PEL*	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
ACENAPHTHENE	UG/KG	6.71	88.9	1.38	1.3 U	1.3 U	1.4 U	1.4 U	1.4 U
ACENAPHTHYLENE	UG/KG	5.87	127.87	1.06	**15 J**	1.1 U	1.1 U	1 U	1.1 U
ANTHRACENE	UG/KG	46.85	245	0.202	0.2 U	0.2 U	0.2 U	0.2 U	0.21 U
BENZO(A)ANTHRACENE	UG/KG	74.83	692.53	0.212	0.21 U	0.21 U	0.21 U	0.21 U	0.22 U
BENZO(A)PYRENE	UG/KG	88.81	763.22	0.176	0.17 U	0.18 U	0.18 U	0.17 U	**0.35 J P**
BENZO(B)FLUORANTHENE	UG/KG	--	--	0.458	0.45 U	0.46 U	0.46 U	0.45 U	0.47 U
BENZO(K)FLUORANTHENE	UG/KG	--	--	0.152	0.15 U	0.15 U	0.15 U	0.15 U	0.16 U
BENZO(GHI)PERYLENE	UG/KG	--	--	0.458	0.45 U	0.46 U	0.46 U	0.45 U	0.47 U
CHRYSENE	UG/KG	107.77	845.98	0.174	0.17 U	0.17 U	0.18 U	0.17 U	0.18 U
DIBENZO(A,H)ANTHRACENE	UG/KG	6.22	134.61	1.1	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
FLUORANTHENE	UG/KG	112.82	1493.5	0.348	0.34 U	0.35 U	0.35 U	0.34 U	0.36 U
FLUORENE	UG/KG	21.17	144.35	0.27	0.26 U	0.27 U	0.27 U	0.27 U	0.28 U
INDENO(1,2,3-CD)PYRENE	UG/KG	--	--	0.27	0.26 U	0.27 U	0.27 U	0.27 U	0.28 U
1-METHYLNAPHTHALENE	UG/KG	--	--	1.48	1.4 U	1.5 U	1.5 U	1.5 U	1.5 U
2-METHYLNAPHTHALENE	UG/KG	20.21	201.28	1.3	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
NAPHTHALENE	UG/KG	34.57	390.64	1.28	1.2 U	1.3 U	1.3 U	1.3 U	1.3 U
PHENANTHRENE	UG/KG	86.68	543.53	0.282	0.28 U	0.28 U	0.28 U	0.28 U	0.29 U
PYRENE	UG/KG	152.66	1397.6	0.328	0.32 U	0.33 U	0.33 U	0.32 U	0.34 U
TOTAL PAHS (ND=0)	UG/KG	1684.1	16770	--	**15**	0	0	0	**0.35**
TOTAL PAHS (ND=1/2DL)	UG/KG	1684.1	16770	--	**19.78**	**5.515**	**5.52**	**5.44**	**5.83**

*****Source*: Buchman 1999

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

TEL = threshold effects level

PEL = probable effects level

J = value is estimated

P = greater than 25% difference between two GC column

U = not detected

TABLE D-8. PCB CONGENER CONCENTRATIONS (UG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	TEL**	PEL**	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
PCB 8 (BZ)*	UG/KG	--	--	0.39	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
PCB 18 (BZ)*	UG/KG	--	--	0.31	0.31 U	0.31 U	0.31 U	0.31 U	0.31 U
PCB 28 (BZ)*	UG/KG	--	--	0.46	0.46 U	0.46 U	0.46 U	**0.67 J**	0.46 U
PCB 44 (BZ)*	UG/KG	--	--	0.13	0.13 U	0.13 U	0.13 U	**0.34 J**	0.13 U
PCB 49 (BZ)	UG/KG	--	--	0.12	0.12 U	0.12 U	0.12 U	**0.26 J**	0.12 U
PCB 52 (BZ)*	UG/KG	--	--	0.16	0.16 U	0.16 U	0.16 U	**0.41 J**	0.16 U
PCB 66 (BZ)*	UG/KG	--	--	0.1	0.1 U	0.1 U	0.1 U	**0.12 J**	0.1 U
PCB 77 (BZ)*	UG/KG	--	--	0.22	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
PCB 87 (BZ)	UG/KG	--	--	0.18	0.18 U	0.18 U	0.18 U	**0.25 J**	0.18 U
PCB 101 (BZ)*	UG/KG	--	--	0.23	0.23 U	0.23 U	0.23 U	**0.28 J**	0.23 U
PCB 105 (BZ)*	UG/KG	--	--	0.17	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U
PCB 118 (BZ)*	UG/KG	--	--	0.084	0.084 U	0.084 U	0.084 U	**0.24 J**	0.084 U
PCB 126 (BZ)*	UG/KG	--	--	0.21	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U
PCB 128 (BZ)*	UG/KG	--	--	0.11	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U
PCB 138 (BZ)*	UG/KG	--	--	0.18	0.18 U	0.18 U	0.18 U	**0.2 J**	0.18 U
PCB 153 (BZ)*	UG/KG	--	--	0.12	0.12 U	0.12 U	0.12 U	**0.22 J**	0.12 U

*PCB congeners used for Total PCB summation, as per Table 9-3 of the ITM (USEPA/USACE 1998)

***Source: Buchman 1999*

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

TEL = threshold effects level

PEL = probable effects level

J = value is estimated

U = not detected

TABLE D-8. (CONTINUED)

ANALYTE	UNITS	TEL**	PEL**	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
PCB 156 (BZ)	UG/KG	--	--	0.12	0.12 U	0.12 U	0.12 U	0.12 U	0.12 U
PCB 169 (BZ)*	UG/KG	--	--	0.12	0.12 U	0.12 U	0.12 U	0.12 U	0.12 U
PCB 170 (BZ)*	UG/KG	--	--	0.24	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U
PCB 180 (BZ)*	UG/KG	--	--	0.58	0.58 U	0.58 U	0.58 U	0.58 U	0.58 U
PCB 183 (BZ)	UG/KG	--	--	0.11	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U
PCB 184 (BZ)	UG/KG	--	--	0.098	0.098 U	0.098 U	0.098 U	0.098 U	0.098 U
PCB 187 (BZ)*	UG/KG	--	--	0.12	0.12 U	0.12 U	0.12 U	0.12 U	0.12 U
PCB 195 (BZ)	UG/KG	--	--	0.23	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U
PCB 206 (BZ)	UG/KG	--	--	0.12	0.12 U	0.12 U	0.12 U	0.12 U	0.12 U
PCB 209 (BZ)	UG/KG	--	--	0.26	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
TOTAL PCBS (ND=0)	UG/KG	21.55	188.79	--	0	0	0	4.96	0
TOTAL PCBS (ND=1/2DL)	UG/KG	21.55	188.79	--	3.934	3.934	3.934	7.43	3.934

*PCB congeners used for Total PCB summation, as per Table 9-3 of the ITM (USEPA/USACE 1998)
***Source*: Buchman 1999
NOTE: Shaded and bold values represent detected concentrations.
MDL = method detection limit
TEL = threshold effects level
PEL = probable effects level
J = value is estimated
U = not detected

TABLE D-9. CHLORINATED PESTICIDE CONCENTRATIONS (UG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	TEL*	PEL*	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
4,4'-DDD	UG/KG	1.22	7.81	0.0798	0.078 U	0.08 U	0.09 U	0.079 U	0.082 U
4,4'-DDE	UG/KG	2.07	374.17	0.0798	0.064 U	0.071 U	0.071 U	0.07 U	0.073 U
4,4'-DDT	UG/KG	1.19	4.77	0.0902	0.088 U	0.09 U	0.09 U	0.09 U	0.093 U
ALDRIN	UG/KG	--	--	0.078	0.076 U	0.078 U	0.078 U	0.078 U	0.08 U
ALPHA-BHC	UG/KG	--	--	0.0644	0.063 U	0.064 U	0.065 U	0.064 U	0.066 U
BETA-BHC	UG/KG	--	--	0.142	0.14 U	0.19 U	0.14 U	0.14 U	0.15 U
CHLORDANE	UG/KG	2.26	4.79	0.584	0.57 U	0.58 U	0.59 U	0.58 U	0.6 U
DELTA-BHC	UG/KG	--	--	0.0594	0.058 U	0.058 U	0.08 U	0.059 U	0.061 U
DIELDRIN	UG/KG	0.715	4.3	0.0712	0.07 U	0.071 U	0.071 U	0.071 U	0.073 U
ENDOSULFAN I	UG/KG	--	--	0.0878	0.086 U	0.088 U	0.088 U	0.087 U	0.09 U
ENDOSULFAN II	UG/KG	--	--	0.0616	0.08 U	0.062 U	0.062 U	0.061 U	0.063 U
ENDOSULFAN SULFATE	UG/KG	--	--	0.0656	0.063 U	0.064 U	0.066 U	0.065 U	0.067 U
ENDRIN	UG/KG	--	--	0.192	0.19 U	0.19 U	0.14 U	0.14 U	0.2 U
ENDRIN ALDEHYDE	UG/KG	--	--	0.0722	0.071 U	0.072 U	0.072 U	0.072 U	0.073 U
GAMMA-BHC	UG/KG	0.32	0.99	0.0684	0.067 U	0.068 U	0.069 U	0.068 U	0.07 U
HEPTACHLOR	UG/KG	--	--	0.0898	**0.11 J P**	**0.15 J P**	**0.16 J P**	**0.17 J P**	**0.16 J P**
HEPTACHLOR EPOXIDE	UG/KG	--	--	0.0868	0.085 U	0.087 U	0.087 U	0.086 U	0.089 U
METHOXYCHLOR	UG/KG	--	--	0.198	0.19 U	0.2 U	0.2 U	0.2 U	0.2 U
MIREX	UG/KG	--	--	0.037	0.036 U	0.037 U	0.037 U	0.037 U	0.038 U
TOXAPHENE	UG/KG	--	--	9.88	9.7 U	9.9 U	9.9 U	9.9 U	10 U

**Source*: Buchman 1999

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

TEL = threshold effects level

PEL = probable effects level

J = value is estimated

P = greater than 25% difference between two GC column

U = not detected

TABLE D-10. ORGANOPHOSPHORUS PESTICIDE CONCENTRATIONS (UG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
AZINPHOS-METHYL	UG/KG	5.62	5.5 U	5.6 U	5.6 U	5.6 U	5.8 U
DEMETON	UG/KG	9.56	9.3 U	9.6 U	9.6 U	9.5 U	9.8 U
ETHYL PARATHION	UG/KG	5.46	5.3 U	5.5 U	5.5 U	5.4 U	5.6 U
MALATHION	UG/KG	6.18	6 U	6.2 U	6.2 U	6.1 U	6.4 U
METHYL PARATHION	UG/KG	4.7	4.6 U	4.7 U	4.7 U	4.7 U	4.8 U

There are no TEL and PEL values for the tested organophosphorus pesticides

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

U = not detected

TABLE D-11. SVOC CONCENTRATIONS (UG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	TEL*	PEL*	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
BENZOIC ACID	UG/KG	--	--	31.6	31 U	32 U	32 U	31 U	32 U
BENZYL ALCOHOL	UG/KG	--	--	27	26 U	27 U	27 U	27 U	28 U
BIS(2-CHLOROETHOXY) METHANE	UG/KG	--	--	31.6	31 U	32 U	32 U	31 U	32 U
BIS(2-CHLOROETHYL) ETHER	UG/KG	--	--	29.2	29 U	29 U	29 U	29 U	30 U
BIS(2-ETHYLHEXYL) PHTHALATE	UG/KG	182.16	2646.51	32	31 U	32 U	32 U	32 U	33 U
4-BROMOPHENYL PHENYL ETHER	UG/KG	--	--	32	31 U	32 U	32 U	32 U	33 U
BUTYL BENZYL PHTHALATE	UG/KG	--	--	32.6	32 U	33 U	33 U	32 U	33 U
4-CHLORO-3-METHYLPHENOL	UG/KG	--	--	37	36 U	37 U	37 U	37 U	38 U
2-CHLORONAPHTHALENE	UG/KG	--	--	27	26 U	27 U	27 U	27 U	28 U
2-CHLOROPHENOL	UG/KG	--	--	27.2	27 U	27 U	27 U	27 U	28 U
4-CHLOROPHENYL PHENYL ETHER	UG/KG	--	--	29.6	29 U	30 U	30 U	29 U	30 U
DIBENZOFURAN	UG/KG	--	--	32	31 U	32 U	32 U	32 U	33 U
DI-N-BUTYL PHTHALATE	UG/KG	--	--	33.4	33 U	33 U	34 U	33 U	34 U
3,3'-DICHLOROBENZIDINE	UG/KG	--	--	23.4	23 U	23 U	24 U	23 U	24 U
2,4-DICHLOROPHENOL	UG/KG	--	--	33.2	33 U	33 U	33 U	33 U	34 U
DIETHYL PHTHALATE	UG/KG	--	--	33	32 U	33 U	33 U	33 U	34 U
4,6-DINITRO-2-METHYLPHENOL	UG/KG	--	--	42.4	41 U	42 U	43 U	42 U	44 U
2,4-DIMETHYLPHENOL	UG/KG	--	--	38	37 U	38 U	38 U	38 U	39 U
2,4-DINITROPHENOL	UG/KG	--	--	50.8	50 U	51 U	51 U	50 U	52 U

**Source*: Buchman 1999

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

TEL = threshold effects level

PEL = probable effects level

U = not detected

TABLE D-11. (CONTINUED)

ANALYTE	UNITS	TEL*	PEL*	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
2,4-DINITROTOLUENE	UG/KG	--	--	31	30 U	31 U	31 U	31 U	32 U
2,6-DINITROTOLUENE	UG/KG	--	--	33.6	33 U	34 U	34 U	33 U	34 U
1,2-DIPHENYLHYDRAZINE	UG/KG	--	--	38	37 U	38 U	38 U	38 U	39 U
DI-N-OCTYL PHTHALATE	UG/KG	--	--	36.8	36 U	37 U	37 U	36 U	38 U
HEXACHLOROBENZENE	UG/KG	--	--	30.4	30 U	30 U	31 U	30 U	31 U
HEXACHLOROBUTADIENE	UG/KG	--	--	26	25 U	26 U	26 U	26 U	27 U
HEXACHLOROCYCLOPENTADIENE	UG/KG	--	--	23	22 U	23 U	23 U	23 U	24 U
HEXACHLOROETHANE	UG/KG	--	--	29	28 U	29 U	29 U	29 U	30 U
ISOPHORONE	UG/KG	--	--	31.4	31 U	31 U	32 U	31 U	32 U
2-METHYLPHENOL	UG/KG	--	--	28.8	28 U	29 U	29 U	29 U	29 U
4-METHYLPHENOL	UG/KG	--	--	68.4	67 U	68 U	69 U	68 U	70 U
NITROBENZENE	UG/KG	--	--	29.6	29 U	30 U	30 U	29 U	30 U
2-NITROPHENOL	UG/KG	--	--	29.2	29 U	29 U	29 U	29 U	30 U
4-NITROPHENOL	UG/KG	--	--	29.2	29 U	29 U	29 U	29 U	30 U
N-NITROSODI-N-PROPYLAMINE	UG/KG	--	--	31.6	31 U	32 U	32 U	31 U	32 U
N-NITROSODIMETHYLAMINE	UG/KG	--	--	25	24 U	25 U	25 U	25 U	26 U
N-NITROSODIPHENYLAMINE	UG/KG	--	--	34.6	34 U	35 U	35 U	34 U	35 U
2,2'-OXYBIS(1-CHLOROPROPANE)	UG/KG	--	--	27.6	27 U	28 U	28 U	27 U	28 U
PENTACHLOROPHENOL	UG/KG	--	--	30.2	30 U	30 U	30 U	30 U	31 U
PHENOL	UG/KG	--	--	27	26 U	27 U	27 U	27 U	28 U
1,2,4-TRICHLOROBENZENE	UG/KG	--	--	28	27 U	28 U	28 U	28 U	29 U
2,4,6-TRICHLOROPHENOL	UG/KG	--	--	26	25 U	26 U	26 U	26 U	27 U

**Source*: Buchman 1999

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

TEL = threshold effects level

PEL = probable effects level

U = not detected

TABLE D-12. VOC CONCENTRATIONS (UG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
ACROLEIN	UG/KG	18.2	18 U	18 U	18 U	18 U	19 U
ACRYLONITRILE	UG/KG	15.8	15 U	16 U	16 U	16 U	16 U
BENZENE	UG/KG	1.24	1.2 U	1.2 U	1.3 U	1.2 U	1.3 U
BROMODICHLOROMETHANE	UG/KG	1.56	1.5 U	1.6 U	1.6 U	1.5 U	1.6 U
BROMOFORM	UG/KG	0.648	0.63 U	0.65 U	0.65 U	0.64 U	0.67 U
BROMOMETHANE	UG/KG	1.42	1.4 U	1.4 U	1.4 U	1.4 U	1.5 U
2-BUTANONE	UG/KG	1.4	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
CARBON TETRACHLORIDE	UG/KG	1.42	1.4 U	1.4 U	1.4 U	1.4 U	1.5 U
CHLOROETHANE	UG/KG	3.2	3.1 U	3.2 U	3.2 U	3.2 U	3.3 U
2-CHLOROETHYL VINYL ETHER	UG/KG	11	11 U	11 U	11 U	11 U	11 U
CHLOROFORM	UG/KG	1.48	1.4 U	1.5 U	1.5 U	1.5 U	1.5 U
CHLOROMETHANE	UG/KG	1.68	1.6 U	1.7 U	1.7 U	1.7 U	1.7 U
DIBROMOCHLOROMETHANE	UG/KG	0.996	0.98 U	1 U	1 U	1 U	1 U
1,2-DICHLOROBENZENE	UG/KG	0.966	0.94 U	0.97 U	0.97 U	0.96 U	0.99 U
1,3-DICHLOROBENZENE	UG/KG	1.12	1.1 U	1.1 U	1.1 U	1.1 U	1.2 U
1,4-DICHLOROBENZENE	UG/KG	0.758	0.74 U	0.76 U	0.76 U	0.75 U	0.78 U
TRANS-1,2-DICHLOROETHENE	UG/KG	1.2	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
DICHLORODIFLUOROMETHANE	UG/KG	2.72	2.7 U	2.7 U	2.7 U	2.7 U	2.8 U
1,1-DICHLOROETHANE	UG/KG	1.66	1.6 U	1.7 U	1.7 U	1.6 U	1.7 U
1,2-DICHLOROETHANE	UG/KG	0.908	0.89 U	0.91 U	0.91 U	0.9 U	0.93 U
1,1-DICHLOROETHENE	UG/KG	1.56	1.5 U	1.6 U	1.6 U	1.5 U	1.6 U
1,2-DICHLOROPROPANE	UG/KG	1.5	1.5 U	1.5 U	1.5 U	1.5 U	1.5 U
CIS-1,3-DICHLOROPROPENE	UG/KG	1.18	1.1 U	1.2 U	1.2 U	1.2 U	1.2 U
TRANS-1,3-DICHLOROPROPENE	UG/KG	0.966	0.94 U	0.97 U	0.97 U	0.96 U	0.99 U
ETHYLBENZENE	UG/KG	1.02	1 U	1 U	1 U	1 U	1.1 U
METHYLENE CHLORIDE	UG/KG	6.36	6.2 U	6.4 U	6.4 U	6.3 U	6.5 U

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

U = not detected

TABLE D-12. (CONTINUED)

ANALYTE	UNITS	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
1,1,2,2-TETRACHLOROETHANE	UG/KG	0.682	0.67 U	0.68 U	0.68 U	0.68 U	0.7 U
TETRACHLOROETHENE	UG/KG	1.28	1.2 U	1.3 U	1.3 U	1.3 U	1.3 U
TOLUENE	UG/KG	1.14	1.1 U	1.1 U	1.2 U	1.1 U	1.2 U
1,1,1-TRICHLOROETHANE	UG/KG	1.58	1.5 U	1.6 U	1.6 U	1.6 U	1.6 U
1,1,2-TRICHLOROETHANE	UG/KG	0.854	0.83 U	0.85 U	0.86 U	0.85 U	0.88 U
TRICHLOROETHENE	UG/KG	1.42	1.4 U	1.4 U	1.4 U	1.4 U	1.5 U
TRICHLOROFLUOROMETHANE	UG/KG	2.9	2.8 U	2.9 U	2.9 U	2.9 U	3 U
VINYL CHLORIDE	UG/KG	1.58	1.5 U	1.6 U	1.6 U	1.6 U	1.6 U

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

U = not detected

TABLE D-13. DIOXIN AND FURAN CONGENER CONCENTRATIONS (NG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	RL	TEF*	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
2,3,7,8-TCDD	NG/KG	0.158	1	0.154 U	0.116 U	0.152 U	0.132 U	0.236 U
1,2,3,7,8-PECDD	NG/KG	0.063	1	**0.116 EMPC**	**0.0928**	**0.215**	**0.142**	**0.143**
1,2,3,4,7,8-HXCDD	NG/KG	0.094	0.1	**0.174 EMPC**	**0.161**	**0.219 EMPC**	**0.32 EMPC**	**0.29 EMPC**
1,2,3,6,7,8-HXCDD	NG/KG	0.094	0.1	**0.158**	**0.174**	**0.303 EMPC**	**0.453**	**0.381**
1,2,3,7,8,9-HXCDD	NG/KG	0.093	0.1	**0.298**	**0.256**	**0.36**	**0.658 EMPC**	**0.979**
1,2,3,4,6,7,8-HPCDD	NG/KG	0.114	0.01	**3.3**	**3.02**	**2.23**	**12.9**	**10**
OCDD	NG/KG	0.387	0.0001	**134**	**125**	**70.4**	**618**	**325**
2,3,7,8-TCDF	NG/KG	0.093	0.1	**0.212**	**0.241**	**0.174**	**0.16 EMPC**	**0.248**
1,2,3,7,8-PECDF	NG/KG	0.044	0.05	**0.0901 EMPC**	**0.0852**	**0.202**	0.048 U	0.0373 U
2,3,4,7,8-PECDF	NG/KG	0.039	0.5	**0.0961**	**0.108 EMPC**	**0.232**	**0.0946**	**0.0766 EMPC**
1,2,3,4,7,8-HXCDF	NG/KG	0.048	0.1	**0.0861 EMPC**	**0.0985 EMPC**	**0.236**	**0.0879**	**0.0911**
1,2,3,6,7,8-HXCDF	NG/KG	0.046	0.1	**0.0881 EMPC**	**0.072**	**0.18 EMPC**	**0.0721 EMPC**	**0.0849**
2,3,4,6,7,8-HXCDF	NG/KG	0.052	0.1	**0.0941 EMPC**	**0.106**	**0.225**	**0.0743 EMPC**	0.0586 U
1,2,3,7,8,9-HXCDF	NG/KG	0.068	0.1	**0.0901**	**0.09 EMPC**	**0.21 EMPC**	0.0678 U	**0.09 EMPC**
1,2,3,4,6,7,8-HPCDF	NG/KG	0.067	0.01	**0.246**	**0.165**	**0.324**	**0.369 EMPC**	**0.323 EMPC**
1,2,3,4,7,8,9-HPCDF	NG/KG	0.099	0.01	0.108 U	**0.134 EMPC**	**0.204**	0.108 U	0.0909 U
OCDF	NG/KG	0.158	0.0001	**0.52**	**0.331**	**0.673**	**0.854**	**0.795**
DIOXIN TEQ (ND=0)	NG/KG	--	--	**0.173**	**0.242**	**0.475**	**0.434**	**0.454**
DIOXIN TEQ (ND=1/2)	NG/KG	--	--	**0.25**	**0.3**	**0.551**	**0.505**	**0.576**

**Source:* Van den Berg, et al. 1998

NOTE: Shaded and bold values represent detected concentrations.

RL = reporting limit

EMPC = estimated maximum possible concentration

TEQ = toxicity equivalency quotient

TEF = toxicity equivalency factor

U = not detected

TABLE D-14. BUTYLTIN CONCENTRATIONS (UG/KG) IN SEDIMENTS FROM JAMES ISLAND, NOVEMBER 2001

ANALYTE	UNITS	MDL	JAM-002	JAM-005	JAM-007	JAM-009	JAM-010
MONOBUTYLTIN	UG/KG	1.34	1.3 U	1.3 U	1.3 U	1.4 U	1.4 U
DIBUTYLTIN	UG/KG	1.74	1.7 U	1.7 U	1.7 U	**2.9**	1.8 U
TRIBUTYLTIN	UG/KG	2	1.9 U	2 U	1.9 U	2.1 U	2.1 U
TETRABUTYLTIN	UG/KG	2.28	2.2 U	2.2 U	2.2 U	2.4 U	2.4 U

NOTE: Shaded and bold values represent detected concentrations.

MDL = method detection limit

U = not detected

Appendix E:

Submerged Aquatic Vegetation (SAV) Mapping

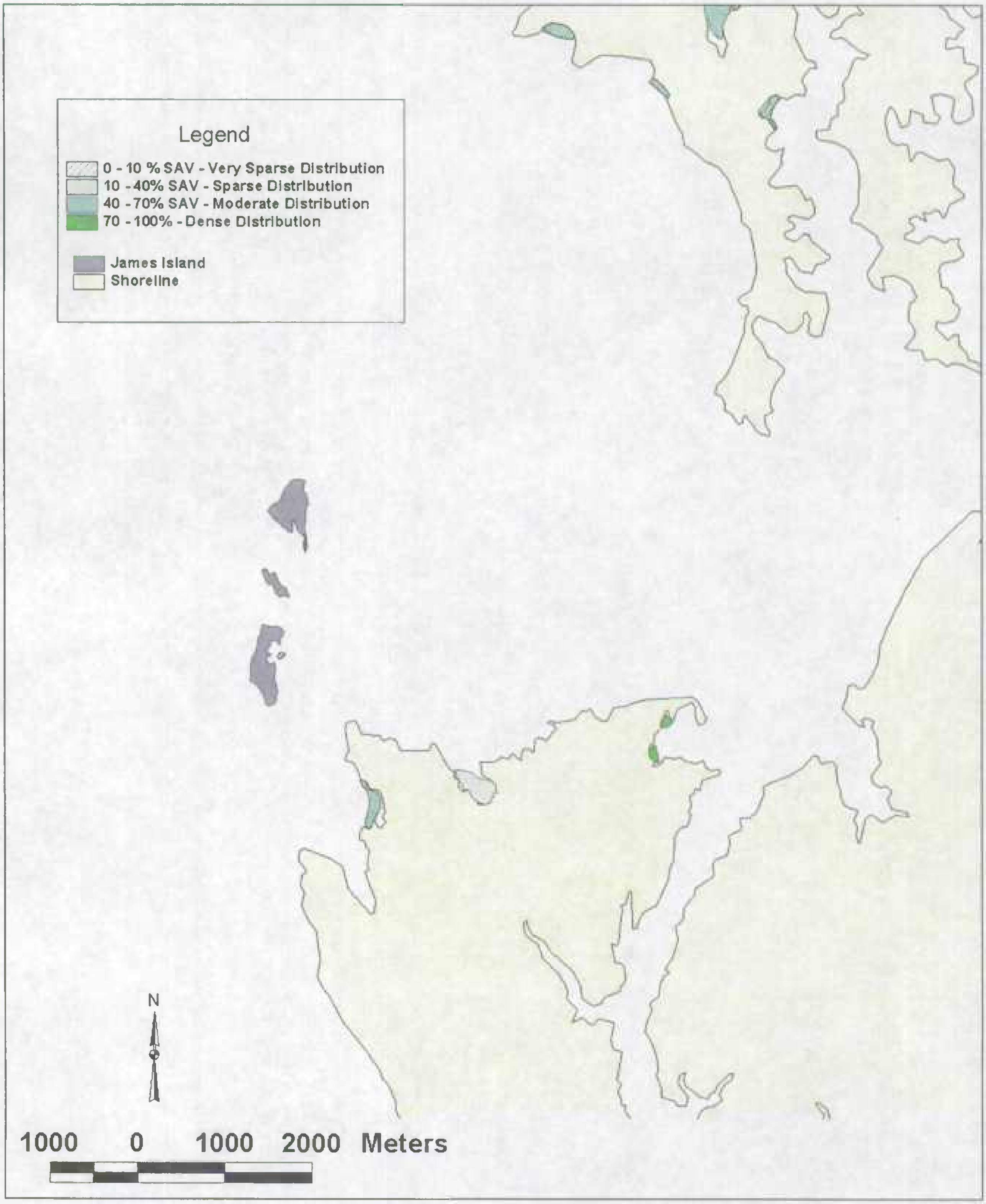


Figure E-1. Submerged Aquatic Vegetation (SAV) Distribution in Vicinity of James Island, 1989

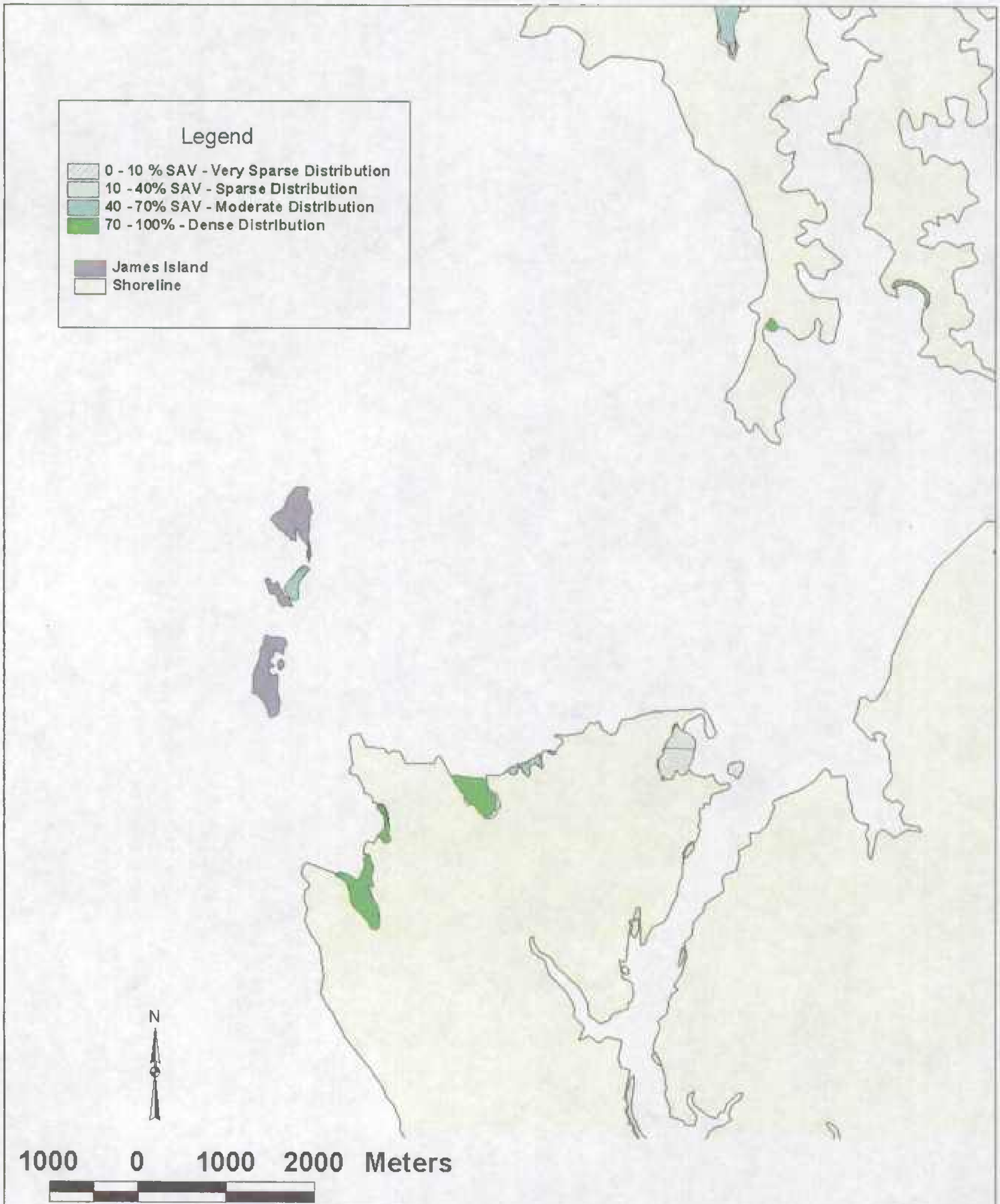


Figure E-2. Submerged Aquatic Vegetation (SAV) Distribution in Vicinity of James Island, 1990

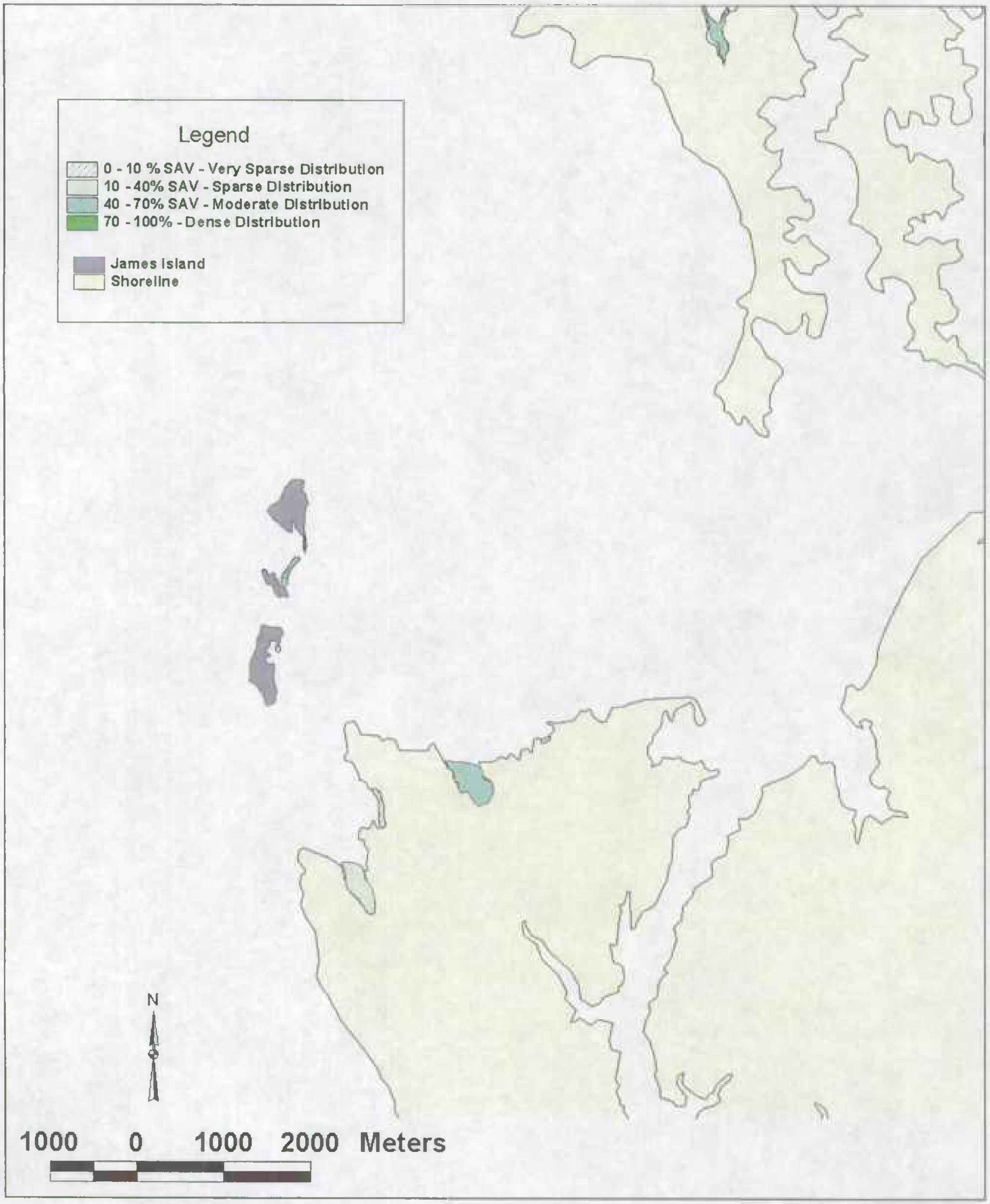


Figure E-3. Submerged Aquatic Vegetation (SAV) Distribution in Vicinity of James Island, 1991

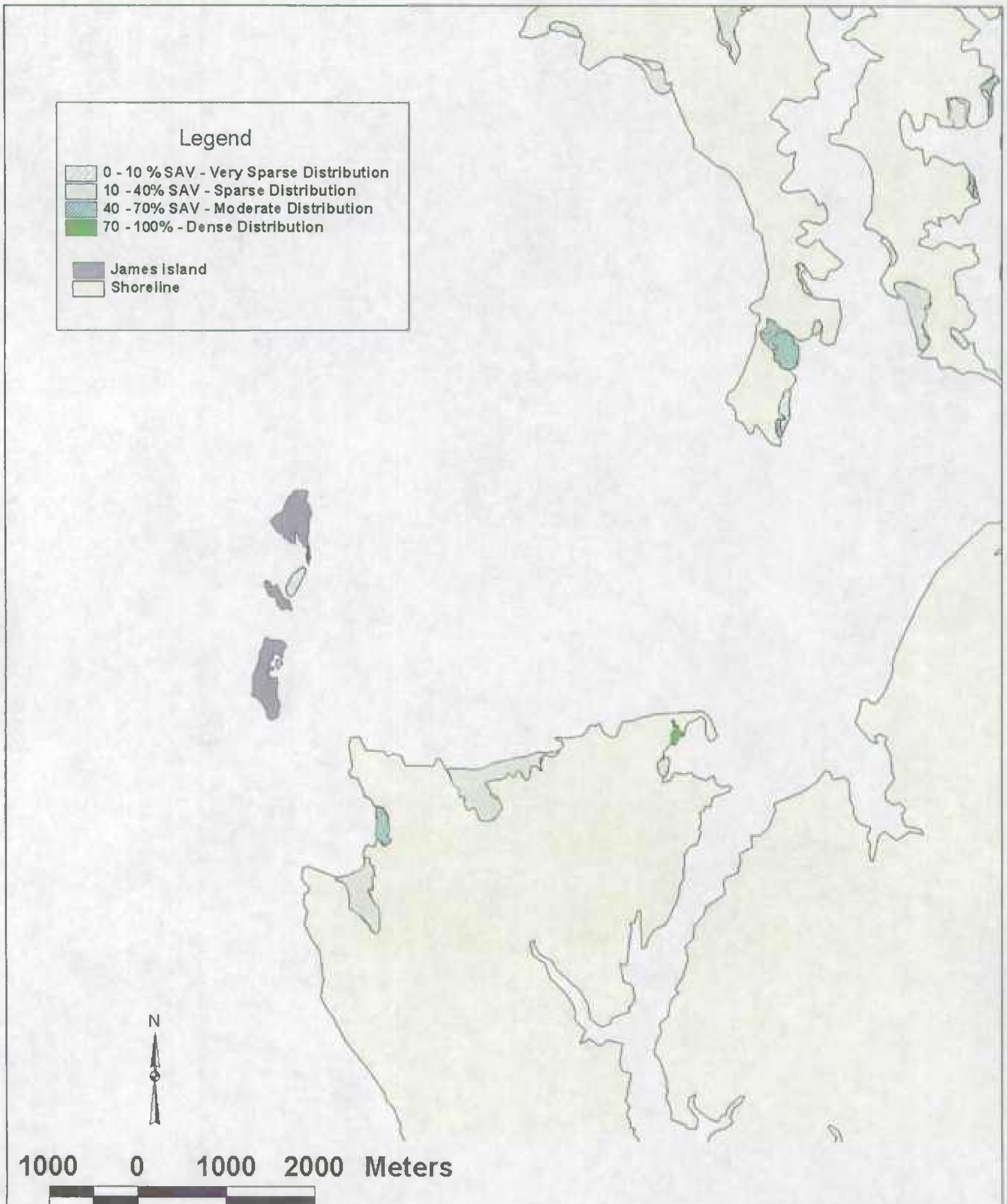


Figure E-4. Submerged Aquatic Vegetation (SAV) Distribution in Vicinity of James Island, 1992

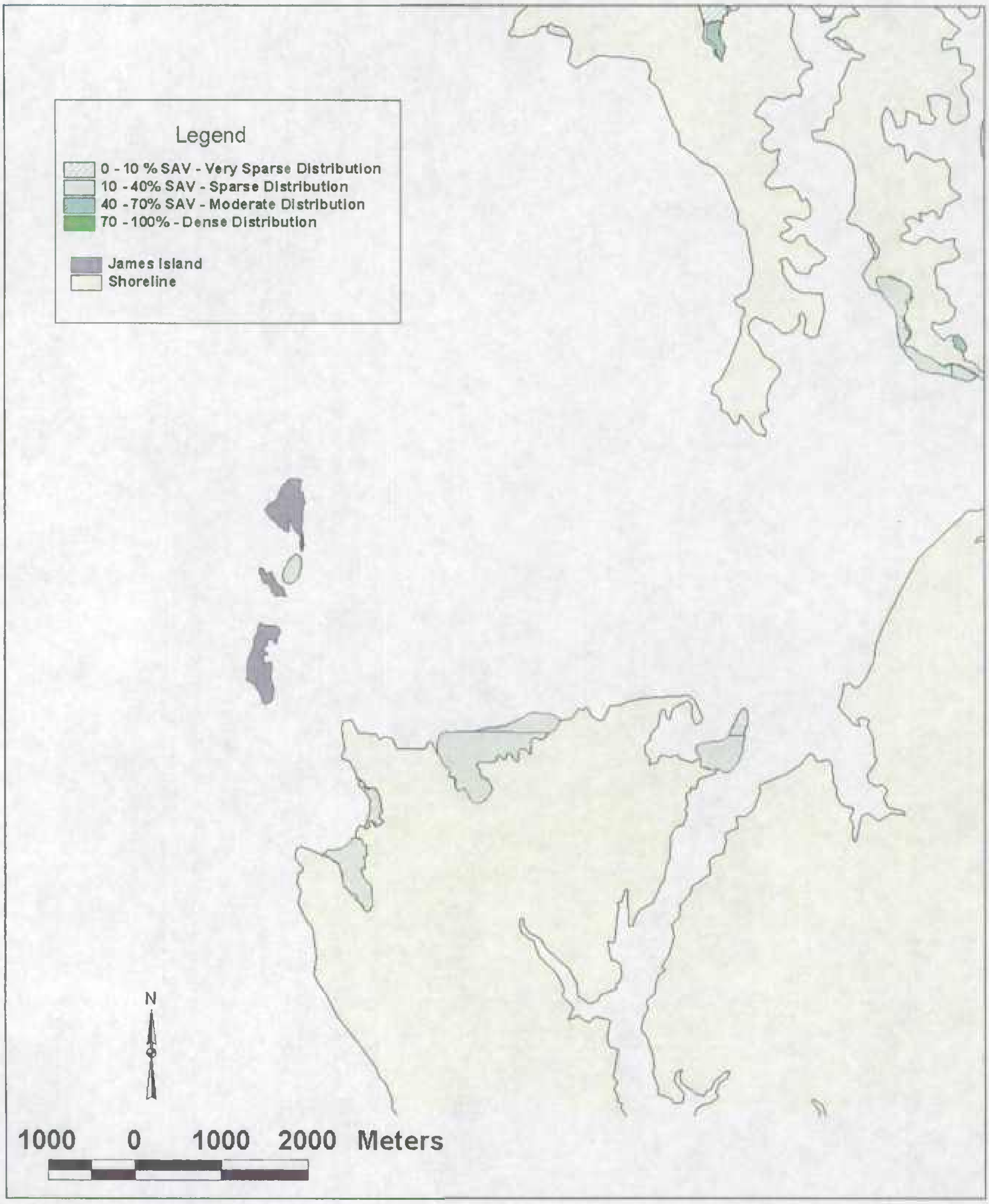


Figure E-5. Submerged Aquatic Vegetation (SAV) Distribution in Vicinity of James Island, 1993

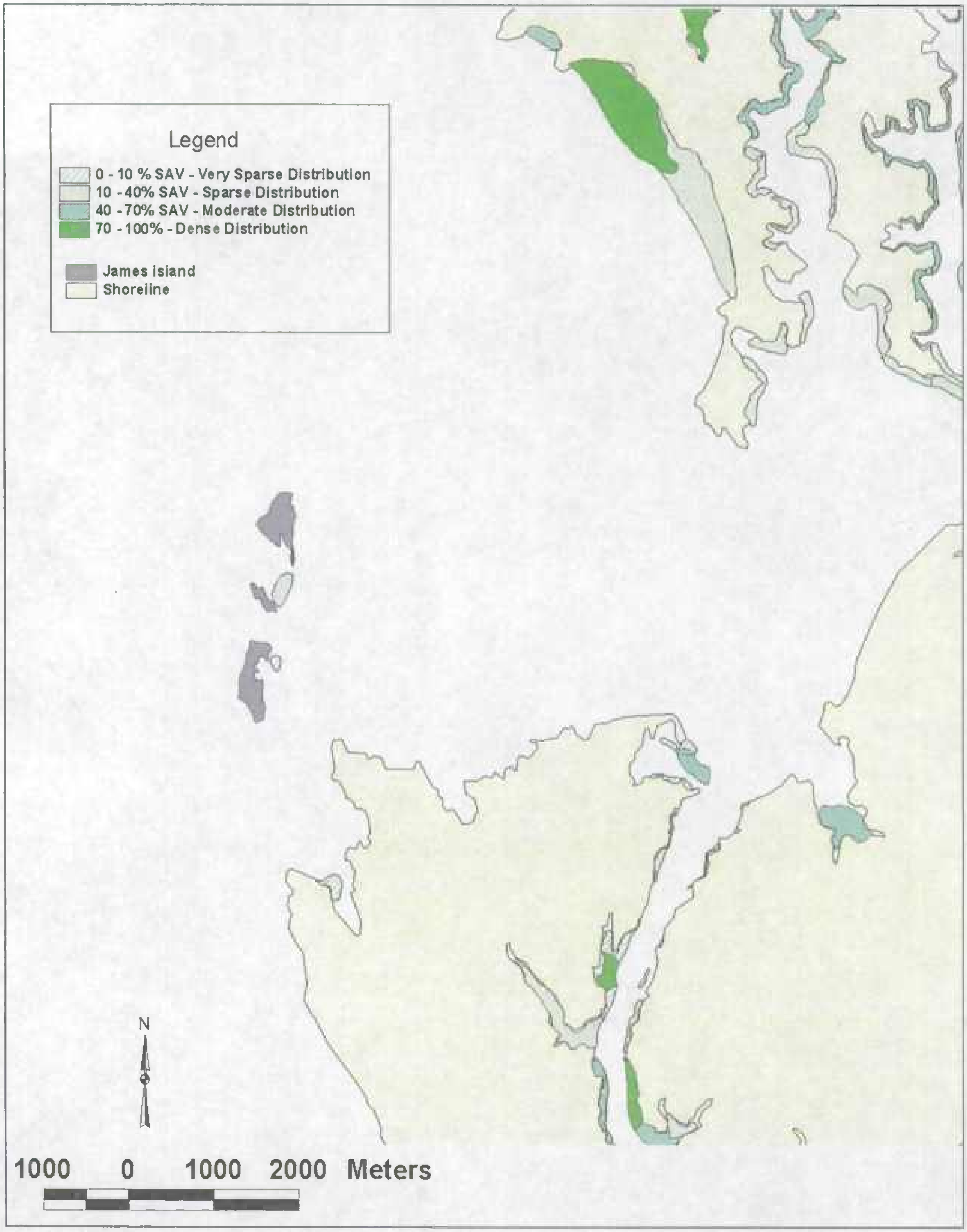


Figure E-6. Submerged Aquatic Vegetation (SAV) Distribution in Vicinity of James Island, 1999